SD-24

Value Engineering: A Guidebook of Best Practices and Tools

June 13, 2011

Office of Deputy Assistant Secretary of Defense
Systems Engineering

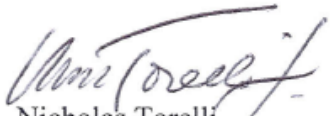
AREA STDZ

Foreword

Assistant Secretary of Defense (Research and Engineering) Zachary Lemnios explained the importance of Value Engineering (VE) to national security in his remarks at the May 12, 2010 Value Engineering Awards Ceremony:

> Across the Department's Research and Engineering enterprise, we are driving Innovation, Speed, and Agility. These coordinates can be applied to the Value Engineering community. They define the approach and operating space in which you work and for which so many are today receiving awards. Innovation, Speed and Agility are critical to transforming how the Department examines processes, provides solutions and fields capabilities to our Warfighters.
>
> Congress and our Secretary have placed an emphasis on a critical examination of, and increased efficiency in, how the Department spends the American tax-payer dollars. Last Saturday, the Secretary of Defense emphasized this priority when he stated that, "The goal is to cut our overhead costs and to transfer those savings to force structure and modernization within the programmed budget." This is no easy task and it falls to you, the Value Engineering community, to lead the way and to the Department to accept this challenge and provide continuous process improvement as part of the solution. The way forward is embedded in the Value Engineering mandate: to identify actions that reduce cost, increase quality, and improve mission capabilities.

This publication shows how VE can be an effective mechanism for generating cost savings or cost avoidance for contractors and the U.S. Government, gives details on the basics of the VE methodology, discusses how to establish a VE program, describes best practices for applying VE on government contracts, and provides an overview of the benefits of a strong VE program. Recommended changes to this publication should be sent to the Defense Standardization Program Office, 8725 John J. Kingman Road, Stop 5100, Fort Belvoir, VA 22060-6220 or email at DSPO@dla.mil.



Nicholas Torelli
Director, Mission Assurance
Office of the Deputy Assistant Secretary of Defense
Systems Engineering

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1. Introduction and Summary

In today's environment of reduced budgets and staffing, the Department of Defense (DOD) can no longer afford the time delays and increased costs that programs have experienced in the past. When one program costs more than planned, decision-makers are forced to delay or cancel other programs. Such actions result in criticisms and may prompt outside involvement by the U.S. Government Accountability Office, the Inspector General, or even Congress. Value Engineering (VE) can play a key role in ensuring that programs stay within budget or even save money.

This document updates information in DOD Handbook 4245.8-H, "Value Engineering," last published in March 1986, and Army Pamphlet 11-3, "Value Engineering" (undated), both of which were used as sources of information.[1] It shows how VE can be an effective mechanism for generating cost savings or cost avoidance for contractors and the U.S. Government. It is intended for multiple audiences. For government practitioners, it gives details on the basics of the VE methodology and discusses how to establish a VE program. For government program office personnel, it explains the impact VE can have on their success. For government contracting officers and industry, it describes best practices for applying VE on government contracts. For both government and industry management, it provides an overview of the benefits of a strong VE program.

A. Value Engineering (VE) Defined

VE is an organized/systematic approach that analyzes the functions of systems, equipment, facilities, services, and supplies to ensure they achieve their essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety.[2] Typically the implementation of the VE process *increases* performance, reliability, quality, safety, durability, effectiveness, or other desirable characteristics.

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1 Jay Mandelbaum and Danny L. Reed, *Value Engineering Handbook*, IDA Paper P-4144 (Alexandria, VA: Institute for Defense Analyses, September 2006) was the first major update of this material. This document is an expanded version of that paper.

2 Office of Management and Budget, *Value Engineering*, Circular No. A-131, 21 May 1993 (available at http://www.whitehouse.gov/omb/circulars_a131).

Because “costs” are measurable, “cost reduction” is often thought of as the sole criterion for a VE application, and indeed, cost reduction is primarily addressed in this document. It is important to recognize, however, that increased value is the real objective of VE, which may not result in an *immediate* cost reduction.

In fundamental terms, VE is an organized way of thinking or looking at an item or a process through a functional approach. It involves an objective appraisal of functions performed by parts, components, products, equipment, procedures, services, and so on—anything that costs money. VE is performed to eliminate or modify any element that significantly contributes to the overall cost without adding commensurate value to the overall function.

VE is not primarily centered on a specific category of the physical sciences; it incorporates available technologies, as well as the principles of economics and business management, into its procedures. When viewed as a management discipline, it uses the total resources available to an organization to achieve broad management objectives. Thus, VE is a systematic and creative approach for attaining a return on investment (by improving what the product or service does in relation to the money spent on it.

1. VE History

During World War II, many manufacturers were forced to use substitute materials and designs as a result of critical material shortages. When the General Electric Company found that many of the substitutes were providing equal or better performance at less cost, it launched an effort (in 1947) to improve product efficiency by intentionally and systematically developing less costly alternatives.

Lawrence D. Miles, a staff engineer for General Electric, led this effort. Miles combined a number of ideas and techniques to develop a successful methodological approach for ensuring value in a product. The concept quickly spread through private industry as the possibilities for large returns from relatively modest investments were recognized. This methodology was originally termed *value analysis* or *value control*.

In 1954, the Navy’s Bureau of Ships became the first DOD organization to establish a formal VE program. Miles and another General Electric employee, Raymond Fountain, set up the Bureau of Ships program to help reduce the cost of ship construction, which had nearly doubled since the end of World War II. The Bureau of Ships asked that the technique be called “Value Engineering” and staffed the office with people under the general engineer position description.

In 1959, the contractual requirement for VE was added to the Armed Services Procurement Regulation, the forerunner of today’s Federal Acquisition Regulation (FAR). VE was initially used only with command approval, but in June 1962, the

Defense Department's procurement regulations were modified to establish VE as a mandatory program both for the Department and for its contractors.

VE was largely a DOD program until Office of Management and Budget (OMB) Circular A-131 was issued in 1988 to expand the program into other organizations "where appropriate." A 1993 reissuance closed several loopholes in the circular and now it requires that all Federal Departments and Agencies use VE and that OMB be advised annually of top VE projects[3], net life-cycle cost savings, cost avoidance, and cost sharing achieved. In 1996, VE was given further support when President Clinton signed Public Law (P.L.) 104-106, which requires each executive agency in the U.S. Government to establish and maintain cost-effective VE procedures and processes.[4]

Since its inception, the VE concept has proven so successful that today it is practiced throughout the world, with many organizations dedicated to its use and promotion.

The DOD VE program continues to have two distinct components:

- An in-house effort performed by DOD military and civilian personnel; and
- An external effort performed by DOD contractors and applied to contracts after Department approval.

This latter component is extremely important. The mandatory VE provisions in most DOD contracts encourage contractor participation and, thereby, realize the full benefits from cost reduction opportunities and innovations. These contract provisions provide the basis for the contractor to obtain a share of the savings that result from an approved VE effort. Before this development, submitting a cost-reduction change led to a commensurate decrease in the size of the contract and usually reduced profit by a proportional amount. The VE provisions changed this paradigm by providing the contractor with an incentive to submit proposals to reduce cost.

2. VE Terminology

The term *Value Engineering* is synonymous with value management, value analysis, and value control. Some of these terms were coined to minimize confusion surrounding the use of the word *engineering* since one does not have to be an engineer to apply VE. The following terms are used throughout this document:

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[3] From a terminology perspective, once a VE project is formulated to address a problem, a VE study is conducted to determine alternative solutions to the problem.

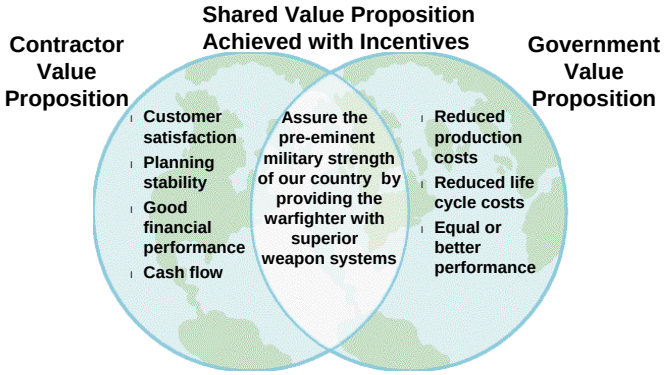
[4] Title 41 USC, Section 432, "Value Engineering" (available at Cornell University Law School's Legal Information Institute site at http://www.law.cornell.edu/uscode/search/display.html?terms=Section 432&url=/uscode/html/uscode41/usc_sec_41_00000432----000-.html).

- **Value Engineering Project:** A preplanned effort to study a specific area or task, with the primary objective of improving value using VE methodology while maintaining required functions.
- **Function:** The purpose or use of an item or process. The VE approach first concerns itself with what the item or process is supposed to do. The consideration of function is the fundamental basis of the VE methodology.
- **Value:** The relationship between the worth or utility of an item (expressed in monetary terms) and the actual monetary cost of the item. The highest value is represented by an item with the essential quality available at the lowest possible overall cost that will reliably perform the required function at the desired time and place.
- **Worth:** The lowest cost to reliably achieve the required function. Worth is established by comparing various alternatives to accomplish that function and selecting the lowest cost alternative.
- **Value Engineering Proposal:** A specific proposal developed internally by DOD personnel for total value improvement from the use of VE techniques. Since Value Engineering Proposals are developed and implemented by government personnel, all resulting savings accrue to the government. A Value Engineering Proposal can also be the result of a technical support contractor effort if it is funded by the government specifically to conduct a VE study on a contract to which it is not a party.
- **Value Engineering Change Proposal (VECP):** A proposal submitted to the government by the contractor in accordance with the VE clause in the contract. A VECP proposes a change to the contract that, if accepted and implemented, provides an eventual, overall cost savings to the government and a substantial share in the savings accrued as a result of implementation of the change for the contractor. It provides a vehicle to reduce acquisition and operating costs while the increasing contractor's rate of return.

General information about VE in DOD can be obtained from the Web site http://ve.ida.org.

B. VE Benefits

As depicted in Figure 1, the government and its contractors depend upon each other to improve their joint value proposition.



Source: Adapted from research into economic initiatives as a result of the Lean Aerospace Initiative.

Figure 1. Joint Government-Industry Value Proposition

While the value propositions are different, there is overlap; actions that benefit one can benefit the other. Incentives are typically used in the contract so that the contractor behaves in a way that will enhance both value propositions. VE provides, and is based on, a shared value concept through incentives for the government, incentives for the contractor, and the equally shared incentive of providing the best possible warfighting capability and systems to the military within the context of a successful business relationship. VE gives industry the incentive to use its best engineering talent to help solve problems that are important to the government.

1. Benefits to the Department of Defense

In today's market, VE has proven to be a sound economic venture. Its overall record of performance (where it has been intelligently applied, discreetly managed, and honestly reported) is impressive. Over the past thirty years, the return on investment on VE projects has been approximately sixteen to one. Figure 2 shows DOD VE savings and cost avoidance since fiscal year (FY) 1981. Cumulatively, more than $47 billion has been saved, with an average savings in the past five years in excess of $2.5 billion.

Equally important is how the savings are used. The dollar savings/assets made available through VE successes may be reapplied within the program, command, or component to finance approved but previously unfunded requirements.

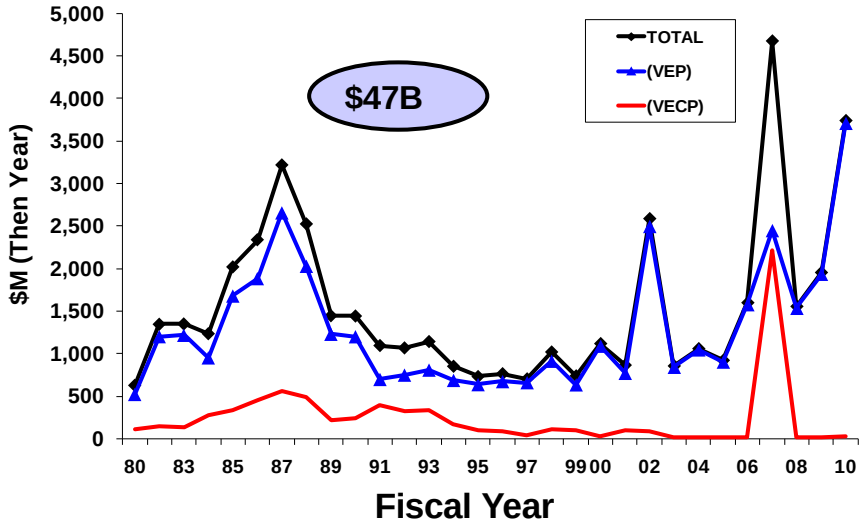


Figure 2. DOD VE Savings and Cost Avoidance

From a qualitative perspective, VE creates opportunities for the Defense Department to achieve long-term benefits in cost reduction, communications, procedures, waste reduction, performance, efficiency, reliability, producibility, quality, effectiveness, readiness, warfighting capability, cycle time, and so on. Conceptually, if VE is planned prior to contract award, the contract can be structured to better take advantage of VECP savings that might develop (e.g., unfunded options that can be exercised with the acceptance of a VECP). In addition, the program manager may take steps to emphasize that VE is "planned for" and is, therefore, an encouraged outcome.

2. Benefits to Contractors

From the contractor's perspective, the benefits of using VE are also substantial. The contractor:

- Shares in the savings that accrue from implementation since VECPs provide a source of profit not available under other provisions of the contract and excluded from profit limitations on government contracts;
- May increase the work to be performed on the contract if the government share is placed back on the contract for previously unfunded efforts;
- May secure a price advantage during system re-procurement after implementing a successful VECP on a previously completed system/item;
- Establishes a reputation as a cost-conscious supplier (the Defense Department presents VE Achievement Awards to contractors);

- Improves communication with the customer;
- Receives reimbursement of development cost on approved VECPs to the extent that such costs are reasonable, allowable, and allocable;
- May obtain usable technology for other product lines; and
- Enhances the retention and growth of corporate technical expertise through advanced technology insertion and fostering a positive working environment.

Each of these benefits relates to the elements of the contractor value proposition shown in Figure 1—customer satisfaction, planning stability, good financial performance, and cash flow. Government personnel need to recognize that contractors take advantage of these benefits by bringing forward VECPs.

C. Potential VE Applications

Many items in the DOD inventory are procured, in large quantities on a regular basis, in accordance with government-developed specifications. Due to advances in technology, materials, and processes, the applicable specifications may be outdated, and "technological regression" by a contractor may be needed to produce to the existing specifications. Items in this category are good candidates for a VE project. Costly, non-value-added contract requirements not directly related to the specifications should not be overlooked, however. For example, packaging, shipping requirements, management reports, etc. may represent a target of opportunity that will require little or no investment by the contractor to achieve a reduced cost of performance under the contract.

Another opportunity for VE occurs when an item was designed and developed on a stringent schedule to meet urgent requirements. Under these conditions, the designers often incorporate "old, reliable" components or subsystems into the design simply because time will not permit qualification of an improved substitute. However, a newer, less expensive, and more reliable alternative may have been developed and proven since the original system was developed. When this situation arises, a VECP to incorporate the improved item or subsystem should be considered.

Diminishing manufacturing sources and material shortages provide significant, and potentially funded, opportunities for VE. DOD components are beginning to program resources to mitigate these very serious problems. Such resources could be a source of funding for nonrecurring costs associated with a VE project. In addition, diminishing manufacturing sources and material shortages may also be established as a life-cycle cost element for categorizing and identifying cost savings.

As discussed in Chapter 2, opportunities for VE projects will typically be derived from a known problem, a cost driver study, or anything indicating that a product or a process should be improved. In the early stages of VE application within an organization,

sophisticated project-selection criteria are not usually needed. Frequently, numerous opportunities exist for VE to offer substantial benefits, such as eliminating high-cost drivers; improving performance, reliability, or producibility; or resolving executive management interest issues.

VE is applicable to all aspects of systems, equipment, facilities, and procedures. This wide range of possibilities is best illustrated by the Defense Department's annual VE awards program, which was established to recognize those individuals and organizations whose efforts have made significant contributions to the Department by identifying VE-related changes that resulted in cost savings or avoidance, quality improvements, or efficiencies. In addition, special recognition is given to initiatives that demonstrate innovative approaches and applications that expand the benefits of VE beyond their traditional scope. Chapter 2 also summarizes, by DOD component, some of the projects associated with the FY 2010 VE awards.

VE is applicable at any point in the life cycle, but the savings potential decreases as the program ages. VE should, therefore, be applied as early as possible in the program life cycle. Early VE tends to produce greater savings (or cost avoidance) because that is where most of the costs are committed—there are greater opportunities for change, and the changes cost less to implement.

However, if early opportunities are missed, VE can still be applied. Late in a program VE is precluded only in those rare instances where the cost of the VE effort and subsequent implementation would be greater than the savings potential. Many systems remain in inventory for a substantial amount of time, often longer than originally planned. While later VE normally adds implementation costs and affects smaller quantities, such deterrents can be offset by improved performance and reliability through advances in technology and by savings generated from increased product life. Chapter 3 describes VE opportunities early in a product life cycle, during production, and after fielding in a systems engineering context. Chapter 4 discusses similar concepts for a construction project.

D. VE Methodology

The VE methodology (referred to as the "job plan") can be applied to any subject or problem. It is a vehicle to carry the project from inception to conclusion. By adhering to certain formalities, the VE job plan ensures that consideration is given to all necessary facets of the problem. Although the job plan divides the study into a distinct set of work elements, judgment is necessary to determine the depth to which each phase is performed as a function of the resources available and the results expected.

The VE job plan divides the task being studied into functions. It provides time for the essential creative work and its necessary analysis so that the best choices can be made

for further development. The job plan leads to the establishment of an effective program aimed at the selection of best value alternatives. It concludes with specific recommendations, the necessary data supporting them, the identification of necessary implementing actions, a proposed implementation schedule, and a required follow-up procedure.

The job plan is normally developed by a value team leader. It is conducted in eight sequential phases (which may overlap in practice) as follows:

1. **Orientation Phase:** Refine the problem statement and prepare for the value study.
2. **Information Phase:** Finalize the scope of the issues to be addressed, targets for improvement, and evaluation factors while building cohesion among team members.
3. **Function Analysis Phase:** Identify the most beneficial areas for study.
4. **Creative Phase:** Develop a large number of ideas for alternative ways to perform each function selected for further study.
5. **Evaluation Phase:** Refine and select the best ideas for development into specific value-improvement recommendations.
6. **Development Phase:** Determine the “best” alternatives for presentation to the decision-maker.
7. **Presentation Phase:** Obtain a commitment to follow a course of action for initiating an alternative.
8. **Implementation Phase:** Obtain final approval of the proposal and facilitate its implementation.

The Orientation Phase is conducted in preparation for the value analysis. This phase, which may last several weeks, lays the groundwork for an efficient and productive study by refining the problem statement, collecting much of the data needed, and organizing for the efforts to follow.

Phases 2 through 7 of the job plan cover the value study. The more analytical steps in the job plan are typically performed in a workshop setting involving all stakeholders. Systematic pursuit of the methodologies within these phases leads to recommendations for improving the existing situation, increasing the value for everyone involved. They conclude with a presentation of recommendations for improvement to the decision-maker.

The Implementation Phase occurs after the value study is over and decisions have been made. It monitors the approval process and implementation of the action plan. The name of the phase may be slightly misleading. Project approval is normally not given

solely on the basis of the brief presentation that occurs at the conclusion of the workshop. Approval will usually be obtained after the completion of follow-up actions such as providing more data and meeting with others. Implementation itself begins when the final approval is granted.

A prime factor in the success or failure of a study is how VE team members conduct themselves in various situations:

- Contacts between members of the VE team and their sources of information,
- Relations within the VE team, and
- Contacts with persons who have the authority to approve or disapprove the changes recommended by the VE team.

"People problems" are sometimes more difficult to resolve than technical problems. For a VE project to be successful, people from all levels of an organization must cooperate to develop a dynamic and creative spirit. Favorable attitudes toward and acceptance of a new concept are based upon positive individual experiences building upon one another over a period of time. Applying general principles of social behavior can promote cooperation in overcoming roadblocks and, thereby, gaining enthusiastic acceptance of VE. Chapter 5 introduces the job plan, discusses some of the people-oriented issues, and addresses how to use the methodology to solve the "right" problem. Chapter 6 discusses the methodology in greater depth.

E. Performing VE on Government Contracts

The basic VE provision in a contract is the VE incentive (VEI) clause in the FAR. The VEI clause is included in most supply/service contracts when the contract price exceeds $100,000. It may also be included at lower thresholds. For example, using the clause for spares/repair kit contracts over $25,000 (if the contract is not for standard commercial parts) is a common practice among many DOD organizations. The VEI clause may also be included in contracts under $100,000 if the contracting officer sees a potential for significant savings. If the VEI clause is in the contract, contractor participation is voluntary, but the FAR also contains provisions in the VE program requirement (VEPR) clause, that require a mandatory VE effort by the contractor. The VEPR clause may be included in initial production solicitations and contracts for major programs if the contracting officer determines that significant savings may result from a sustained, specified VE effort.

Approved VECPs, submitted under the VEI clause, become the basis for modifying a contract to incorporate VE. Before preparing a formal VECP, the contractor should sell or market the VE idea through clear communication with the procuring activity to increase the likelihood of success. This enables the contractor to get an indication from

the government of whether a potential idea should be pursued before significant investments are made. The contractor should become acquainted with the government point of contact or VE advocate who will have the responsibility for evaluating and recommending approval of the VECP. A potential VE idea should be presented early to the appropriate points of contact.

When the contractor makes the decision to submit a VECP, those responsible for preparing it should realize that the chance of the VECP being approved is proportional to the completeness of its preparation. Sufficient information must be presented so that the government can conduct a thorough evaluation within a reasonable amount of time. Failure to provide adequate data will usually result in requests for additional data (which significantly delay the process), but it could also result in the VECP being rejected.

Contractors should prepare a VECP using an approach similar to responding to a formal procurement solicitation. FAR 52.248-1 provides the basis for contractors to submit VECPs in supplies or services contracts. When contractors participate in the VE program by originating, preparing, and submitting VECPs, they will be rewarded for their (and any of their subcontractors') ideas if the ideas are adopted by the procuring activity. FAR Part 48 and 52.248-1 describe the definitions of terms used in VE, the criteria for VECP acceptance, and cost savings sharing arrangements.

While an untapped potential exists to add flexibility and tailor the FAR to accommodate the needs of the government and its contractors, extenuating circumstances in the current contracting environment often add complexity to the VECP process and consequently discourage the use of VECPs.[5] Chapter 7 provides more about VE from a contractor's perspective.

F. Unrealized VE Opportunities

1. Diminishing Manufacturing Sources and Material Shortages (DMSMS)

VE is a systems engineering tool that employs a structured, innovative problem-solving methodology to reduce cost and improve quality and performance. It develops solutions by eliminating unnecessary functions and establishing new combinations of functions to be more responsive to the needs of the customer. Under DMSMS conditions, the resources required to perform a function are increasing, or are about to increase significantly. Therefore, there is a high degree of commonality between the DMSMS risk management process and the VE methodology since VE systematically finds innovative solutions that reduce such costs and increase value.

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5 Refer to Jay Mandelbaum and Danny L. Reed, *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046 (Alexandria, VA: Institute for Defense Analyses, October 2006).

More specifically, VE is an extremely powerful tool and methodology for (1) identifying a large number of resolution options; (2) evaluating their potential for solving the problem; (3) developing recommendations; and (4) providing incentives for the investments needed for successful implementation. Thus, using the VE methodology provides *greater opportunity* for developing and implementing innovative solutions to DMSMS problems.

As such, VE is ideally suited for use in resolving DMSMS issues. The DMSMS community identifies problems (ideally with plenty of lead time to determine a solution) and the VE tool develops solutions to those problems through function analysis. But the synergies are greater than this. The VE-enabled shared savings with the contractor is also a major factor. This concept provides the incentives necessary for the contractor to make investments that will mitigate DMSMS problems. For each DMSMS resolution option, there is evidence of significant benefits that can be achieved with the use of VE.

Chapter 8 provides real examples of how VE was used to acquire expensive, hard to obtain parts in the same way that DMSMS resolution options seek alternative ways to acquire potentially unavailable items or materials. In DOD today, there are many unrealized opportunities to use VE under similar circumstances.

2. Service Contracts

Most VE savings, especially those that are contractor initiated, are based on savings in the acquisition of hardware. However, the government now predominantly spends its contract dollars on services. According to the U.S. Government Accountability Office, about 60 percent of the Federal Government's contract awards are for services. The government acquires all types of services, ranging from routine commercial purchases of courier services, janitorial services, and services of security guards to highly skilled technical, scientific, and engineering services in support of space launches or the development of major weapon systems. FAR 48.201(a) requires that a VE clause (found in FAR 52.248-1) be included in all contracts for supplies and *services* exceeding a specified threshold.

If *the unit price can be changed to reflect the VECP*, then a service contract would operate much the same as a hardware contract and produce similar benefits to both the government and the contractor. While many types of service contracts offer savings opportunities, contracting officers dealing with such contracts often have little to no VE experience. In addition, these contracts present some inherent complexities in calculating how to actually share the savings. The problem with using VE in a service environment is that it is more difficult to:

- Identify the mechanisms for sharing savings, and
- Calculate savings with certainty.

Nevertheless, the difficulties in using VE for service contracts are not insurmountable. Actions could be taken to support the use of VE in service contracts as long as they fall within the parameters of this FAR citation. Chapter 9 contains more information on this topic.

G. Establishing a VE Program

Applying VE to reduce cost and improve performance on a continuous basis involves a systematic approach for managing a VE program within an organization, providing practitioners with the necessary training, working with contractors to encourage and support their participation, expediting contractual approval, and sharing pertinent information with others who want to do the same.

1. Establishing a VE Program in Government

A VE program cannot be established in a vacuum. It must be fully integrated with other organizational activities. Because VE can be thought of as an enterprise change initiative, comparisons are often made to other enterprise change models. Approaches will always have differences, however:

- Each approach will have its own identifiable evolutionary path.
- Some tools and characteristics will be strongly tied to a single approach.
- Each approach may have a different goal, focus, scope, or business model.
- Terminology will be different.
- Individual circumstances can lend themselves to one approach over another.

The differences are not important. All such models will provide a positive impetus for performance improvement and change that will enable organizations to drastically improve their bottom lines. Each approach will use its own process—these processes work, the value methodology works. In fact, the boundaries will merge in practice. While each approach has strengths, rarely will a single approach be right for all aspects of a given situation. The complementary nature of the different approaches will lead to synergistic benefits. Chapter 10 describes these interrelationships using some enterprise-wide initiatives (Lean Six Sigma and Business Process Reengineering) at the Department of Defense.

Top management support, institutionalized in written policy that is adequately resourced, is a prerequisite for a successful VE program. Leadership attention will ensure implementation and continuing support from the entire organization. Setting goals and objectives that are linked to the organization’s affordability initiatives and can be tracked through metrics provide both a rationale for change and an impetus to succeed.

A designated VE leader with open communication channels to top management is also important. That person should have established credibility as a problem solver and possess both people and management skills. Chapter 10 lists some of the leader's responsibilities.

Nearly all colleges and universities teach disciplines related to the practice of VE. Some colleges and universities teach the methodology in greater detail. Within the Department of Defense, the Defense Acquisition University offers an online continuous-learning VE overview module.[6] SAVE International is a professional society devoted to the advancement and promotion of the value methodology. SAVE International offers its members education and training, publications, tools for promoting the value methodology, certification, networking opportunities, and recognition. SAVE also maintains a directory of "value consultants" who can lead studies or train others in VE techniques, and it sponsors courses covering the value methodology in depth as well as related disciplines. In addition, private companies provide VE training to their own employees and their customers. Chapter 11 provides additional information about these resources.

2. Improving VE Expertise in Government and Industry

One of the most effective ways to improve expertise in a subject is to link knowledge seekers with knowledge sources (both written and experiential). Communities of practice (CoPs) are proven vehicles for linking people with experience to others who can benefit from their insight and knowledge.

A CoP is a group of individuals with similar interests that works together to facilitate communication, share knowledge, and solve common problems. CoPs cross organizational lines and geographical boundaries. By nurturing a trust-based culture, CoPs foster interaction among people at different levels and with varying subject matter expertise; they enable group members to develop professional relationships with leaders in the field. By providing a safe environment to share challenges, exchange best practices, and test new ideas, CoPs stimulate collaboration and innovation.

This approach is being applied to VE. The CoP, initially focused on VECPs, has been organized to help practitioners share and learn from one another. It can be accessed by going to the Defense Acquisition University's Acquisition Community Connection Web site, https://acc.dau.mil/CommunityBrowser.aspx?id=399567&lang=en-US. The CoP will help participants navigate the VECP process, improve the probability of successful VECP evaluations, provide assistance and answers to technical questions, and serve as a forum for disseminating the latest information. Contracting officers, VE

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[6] Search for value engineering at https://learn.dau.mil/html/clc/Clc.jsp?fTopic=All&fKeywords=Value+Engineering&Submit=Search.

practitioners, program offices, and industry are all encouraged to use this CoP to share and build on the material contained in this document. Chapter 12 contains the bulk of the material from the Web site and discusses the motivation for this CoP in greater detail.

2. Opportunities for VE Application

This chapter contains three sections. Section A identifies some characteristics of worthwhile VE projects that can be used to establish project-selection criteria. After listing potential VE application areas, Section B summarizes recent examples of actual VE projects the DOD components/agencies have conducted. Section C contains concluding comments.

A. Selecting VE Projects

Like any profitable endeavor, a successful project is based on an adequate return on investment. While almost any activity is a possible VE opportunity, selecting VE projects should be based on the potential yield from the time, talent, and cost that will be invested.

Typically, opportunities for VE projects will be derived from a known problem, a cost driver study, or anything indicating that a product or a process should be improved. In the early stages of VE application within an organization, sophisticated project-selection criteria are not usually needed. VE can frequently offer substantial benefits, particularly when one or more of the following applies:

- High cost;
- Deficiencies in performance, reliability, or producibility;
- Multiple product applications; or
- Executive management interest.

Once the organization's use of VE is more fully established, additional criteria may be applied to select subsequent tasks. Worthwhile candidates usually involve one or more of the following:

- An excessively complex product;
- An accelerated development program;
- An item that field use indicates is deficient in some way, such as high failure rate, low reliability, or low availability;
- An item that uses older technologies for which modernization appears promising;
- A process with long cycle time; or

- A sole-source procurement.

Candidates with both the potential for high impact and leadership interest in finding a solution should be ranked highest.

VE can also be used to measure the merit and the risk of a new or changed process (before a problem is identified),[7] as well as to:

- Eliminate or control potential process failures;
- Identify process parameters that need additional or improved controls to prevent process failures;
- Confirm which elements of a process are robust; and
- Improve product safety, quality, cost, and schedule.

The VE methodology should be applied in the following manner:

1. Form a multidisciplinary team.
2. Identify process functions.
3. Identify potential failure modes.
4. Calculate a risk priority number as a function of the probability the potential failure will occur, the seriousness of the failure, and the probability of detecting a defect.
5. Identify controls to detect or eliminate the failure cause.
6. Develop actions to reduce risk.
7. Reassess the risk priority number with the corrective actions in place.
8. Assign actions and track them.

VE has proven effective in environments such as engineering, laboratories, test facilities, procurement operations, construction projects, manufacturing facilities, and maintenance depots. It has been applied to a broad spectrum of items, procedures, systems, software, equipment, and so on.

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[7] This application is based upon work presented by Glen Curtis, "Process Failure Modes Effects Analysis (PFMEA): 'Reduce Process Risk,'" at the Conference on Quality in the Space and Defense Industries, 21–22 March 2005.

B. Examples

The following are some of the areas in which VE has been applied in the Defense Department:

- Construction;
- Design or equipment modifications;
- Equipment and logistics support;
- Facilities and hardware;
- Manufacturing processes;
- Materiel handling and transportation;
- Packaging/packing and preservation;
- Parts obsolescence;
- Procurement and re-procurement;
- Publications, manuals, procedures, and reports;
- Quality assurance and reliability;
- Salvage, rejected, or excess material;
- Site preparation and adaptation;
- Software (computer) programs and flow charts;
- Software architecture development;
- Specifications/drawings;
- Technical and logistics data;
- Testing, test equipment, and procedures;
- Tooling; and
- Training.

The Defense Department's annual VE awards program recognizes individuals and organizations that have made significant contributions to the Department by identifying VE-related changes resulting in cost savings or cost avoidance, quality improvements, or efficiencies. In addition, special recognition is given to initiatives that demonstrate innovative approaches and applications that expand the benefits of VE beyond their traditional scope (i.e., software; environmental protection and conservation; energy conservation; organization; process; service; performance; reliability; quality; etc.). The remainder of this chapter summarizes, by DOD component/agency, some of the projects identified in the justification for winning one of the annual VE awards.

1. Army

a. Black Hawk Helicopter Dual Stabilator Controller

The Army used a VE team to determine that the antiquated Stabilator Amplifiers on the UH-60 Black Hawk helicopters could be replaced by a sealed, single-box Dual Stabilator Controller (DSC). The DSC is predicted to have significantly better reliability than the previous version and a built-in test (BIT) capability that greatly reduces the maintenance burden imposed by the existing, complicated, test set. The new DSC also reduces the logistics footprint. In addition to increased fleet readiness, the greater reliability will also improve mission performance. The new DSC requires maintenance at a frequency estimated to be less than one-tenth the frequency of the replaced units. Cost to repair each of the new units will drop from over $5000 to under $3000. The increased reliability and reduced maintenance down-time provides the Federal Government with $28.1 million in cost savings/avoidances.

b. Family Medium Tactical Vehicle (FMTV) Competitive Re-buy

The procurement strategy for the FMTV family of vehicles was to procure competitively to a Level III Technical Data Package (TDP). A major component of this truck family, the basic cab, was not addressed in the TDP due to the proprietary nature of its design, and was considered to be a sole sourced item. Through the use of VE function analysis, a study team developed a solicitation to allow non-incumbent bidders to design their own interchangeable cab at low risk. The completion of this development resulted in a VE cost savings/avoidance of $1.4 billion.

c. Unit Maintenance Aerial Recovery Kit (UMARK) Aircraft Sling

The UMARK completed fielding with a total of 301 kits. The UMARK aircraft slings were load test certified at the original equipment manufacturer (OEM) and fielded in accordance with an authorized five-year or twenty mission service life before requiring retirement. The certification of all UMARK aircraft slings, regardless of the number of lifts, was allowed to expire. The estimated total cost to replace all 301 UMARK kits in the field is $7.4 million. A VE study was conducted to determine the most viable and economical approach to retain the UMARK components beyond the five-year and/or twenty lift useful life criteria and to best support the Army aircraft and to maintain UMARK lift safety. The approved study results initiated the action of having the OEM recertify the kits resulting in minimal risk at a savings of $3.6 million over three years.

d. Tool Set Shelters

The Aviation Unit Maintenance (AVUM) Set #2, is an Army Aviation Sets, Kits, Outfits, and Tools (SKOT) used to maintain and repair aircraft at the unit level. The

AVUM Set #2 tool load is integrated into three separate S-280 shelters. Each shelter system is configured differently to accept the unique tool loads for each of the three shelter systems. The current shelters, S-280B/G, were getting old and were structurally inadequate to repair and consequently required replacement. In addition, if the shelter was damaged, another one could not be substituted, it had to be replaced with the exact same system. This VE study was conducted to determine the most viable and economical approach to replace/upgrade the S-280B/G shelter. Since a new procurement of S-280B/G shelters was deemed cost prohibitive, the VE study initiated switching to the S-280C/G shelter with modifications to the inserts which will result in a $317 thousand cost savings/avoidance over three years. By changing to the S-280C/G, the payload and storage increased. Modifying the inserts produced a common design that allowed any of the three shelters to accept any of the SKOT hardware.

e. Brevard County Mid-Reach Shore Protection Project (U.S. Army Corps of Engineers)

Prior to the Value Engineering study, the Mid-Reach Shore Protection Project segment was removed from the 7.8 mile project feasibility report recommended plan due to environmental concerns. Re-evaluation of inclusion of the Mid-Reach segment in the Brevard County Hurricane and Storm Damage Project was authorized as a result of the VE study. The Maximum Benefit Federal Plan (MBFP) and the Compromise Plan (CP - Locally Preferred Plan) were both intended to reduce the damages caused by coastal storms while maintaining the recreational beach and near-shore areas, and maintaining environmental quality. The MBFP (Benefit to Cost Ratio: 4.89:1) and the CP (Benefit to Cost Ratio: 2.37:1) were estimated to cost $51.1 million and $33.6 million respectively. Following the VE study, construction costs were estimated as $29.3 million and annual benefits were identified as $5.1 million (Benefit to Cost Ratio: 2.9:1). Potential/Project Cost Avoidance to the government is $24.2 million. The VE study resulted in a calculated return on investment of 1860 to 1.

f. New Orleans District 100-Year Protection Alternatives (U.S. Army Corps of Engineers)

Prior to the Value Engineering study, the initial project plan consisted of over 30 miles of various levee and floodwall construction along both banks of two canals open to tidal surge (parallel protection). The project required significant property acquisition and facility relocations. The VE study resulted in a major project change from parallel protection to canal closure gate and pump station. Significant performance and efficiency changes to standard pump station design were also adopted. Actual cost avoidance to the government is $240 million. The VE study resulted in a calculated return on investment of approximately 4000 to 1.

g. New Orleans District West Closure Complex (U.S. Army Corps of Engineers)

Prior to the Value Engineering study, the project design called for thirteen 1,540 cubic feet per second pumps and thirteen individual, pre-fabricated, storage tank system. Following the VE study, re-configuration of pump discharge design improved unit performance such that only eleven pumps are required. Use of three, larger size pre-fabricated fuel tanks was also selected. The actual cost avoidance to the Federal Government is $47 million. The VE study resulted in a calculated return on investment of approximately fifty nine to one.

2. Navy

a. AVS-9 Tactical Air Mount

The crew of Navy and Marine Corps fixed wing jets currently use the helmet mount night vision goggle to perform night operations. Each goggle comes with a helmet mount that enables the Aircrewman to mount it to the aviator helmet. This helmet mount currently uses a one-half AA lithium battery. The one-half AA battery is very expensive compared to AA alkaline batteries and is not readily available aboard ship or while forward deployed. The low availability and the process required for disposal of the one-half AA battery reduced the fleet's availability of helmet mount aviation night vision goggle and increased sustainment costs. Additionally, the interface between each goggle and the helmet is made of a plastic composite which over time wears and cracks, causing goggle to go from the stowed position to the operational position suddenly. When the goggle interface on the helmet mount cracks, the goggle will not break away at the required G force.

Using Value Engineering, the Naval Systems Warfare Center Crane team identified the problem; analyzed potential alternatives including redesign of the mount with a newer/stronger composite; and modified the mount's battery pack to accommodate AA alkaline batteries. These modifications greatly reduce battery cost as well as mount replacement costs due to cracking. The net ten-year cost avoidance from this in-house Value Engineering Proposal is expected to be $3.8 million, with a return on investment of 12 to 1.

b. Automated Image Intensifier Measurement System (AIMS)

Image Intensifier Tubes (IITs) are the primary engine that drives the U.S. Armed Forces' ability to operate at night. There is a tremendous demand for IIT devices because of the increasing utilization of night-time operations and the asymmetric advantage night vision devices give U.S. military personnel. Manufacturers are largely unable to meet this demand due to the intensely manual nature of the current inspection processes.

A laboratory study was performed that found approximately 75 percent of the IITs being replaced were actually still serviceable. A leading capability, the AIMS, has been designed and developed that will allow IITs to be inspected and screened at a very high rate and accuracy. Using value methodologies through the study of functions and the analysis of alternatives, the AIMS was developed, as an in-house Value Engineering Proposal, to provide a means of performing those tests that are necessary to identify those IIT's that could be recovered and returned to service, rather than being disposed of unnecessarily. The ten-year estimated cost avoidance is $17.8 million, with a return on investment of 11.5 to 1.

c. ALQ-99 Band 4 Transmitter Output Traveling Wave Tube Modernization

The ALQ-99 Band 4 Transmitter legacy Output Traveling Wave Tubes (OTWTs) have a low production yield and high failure/scrap rate resulting in high spare rate replenishment cost and high Band 4 Transmitter awaiting parts rates. The ALQ-99 Band 4 Transmitter has been a critical, high usage asset in EA-6B contingency operations in support of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF).

A Naval Systems Warfare Center Crane VE Team, using Value Engineering methodologies, identified the problem; analyzed potential alternatives used on other similar technology systems; and, along with L-3 Communications, executed the Band 4 OTWT modernization program. The Band 4 Transmitter's reliability and availability was improved by incorporating a modernized OTWT design approach that results in a high yield, high reliability OTWT. The total life-cycle savings for this in-house Value Engineering Proposal is over 10 million dollars, with a return on investment of 4.5 to 1.

d. Life Extension Refurbishment Program (LERP)

The Port Hueneme Division Naval Surface Warfare Center (PHD NSWC), Ship Defense Department developed and implemented an in-house Value Engineering Proposal for a condition-based Life Extension Refurbishment Program to address fleet readiness concerns with the MK57 North Atlantic Treaty Organization (NATO) SEASPARROW Surface Missile System (NSSMS) and MK23 Target Acquisition System (TAS) top side equipment. The initial emphasis was on the processes for identifying customer needs and assessing the fulfillment of these needs. The team evaluated the processes currently employed by the Material Condition Assessment (MCA) and overhaul programs. Through analysis of the current processes and brainstorming suggestions for process revisions, they identified key processes for improvement.

In response to the fleet's concern, the PHD NSWC Depot Engineering Team developed the Life Extension Refurbishment Program for NSSMS and TAS above deck equipment. Since LERP began, no overhaul requirements have been required due to

condition and LERP is now the standard process for addressing NSSMS and TAS maintenance beyond the organizational level. The key to the LERP's success is the MCA process which ensures that candidates are refurbished before their condition degrades to overhaul requirements.

The solutions developed as a result of the PHD NSWC Depot Engineering Team efforts will continue to provide an effective and cost affective maintenance approach for the future. By performing LERP, the Navy/Federal Government has saved $46 million to date and will save at least $277 million in total life-cycle overhaul dollars while maintaining the NSSMS and TAS units.

e. SSN688 Class Operating Interval Extension

By applying Value Engineering principles, this team conducted a comprehensive review of 115 Los Angeles Class maintenance requirements tied to the submarine's forty-eight month operating interval. The team led detailed analysis and discussions of each maintenance requirement with the appropriate technical authority warrant holders, in-service engineering agents, and life-cycle managers. By examining the inspection results, maintenance actions, repairs, casualty reports and material condition assessment reports accumulated over the past ten years of SSN 688 Class operation, the operating cycle was safely extended from forty-eight months to seventy-two months while subjecting the submarine force to a minimal level of additional operational risk. The VE team effectively and efficiently led this multi-faceted/multi-disciplined effort to completion in six months.

This effort resulted in the elimination of thirty-seven SSN 688 Class Docking Selected Restricted Availabilities (DSRA) and one Pre-Inactivation Restricted Availability and the replacement of thirteen SSN 688 Class DSRAs with significantly smaller Continuous Maintenance Availabilities. Elimination of these Depot Level Maintenance Availabilities is equivalent to approximately 900,000 man days of submarine maintenance. The estimated four year savings is $529 million.

3. Defense Logistics Agency

a. Electron Tube

This item is used on the ALR-69 Radar Warning Receiver. This system detects, identifies, processes and displays airborne interceptor surface to-air-missile and anti-aircraft artillery weapon systems. The system provides the crew with threat type, emitter mode, and threat angle-of-arrival information. This system is used in the F-4 Phantom, the A-10 Thunderbolt, the F-16 Aircraft, the HH-60 Helicopter and the C-130 Aircraft. The Value Analyst contacted Lexel Imaging in an attempt to get Lexel Imaging qualified to produce the receiver. Consequently, Lexel went though First Article Testing and

passed. This process took just less than seven years. The Lexel part number was added to the total item record and Enterprise Business System was updated. Due to the new source offering better value to the government, the unit price was reduced by 56 percent and $546.7 thousand VE savings were realized in the first year of implementation.

b. Antenna

An Army VHF antenna is managed in the Maritime Supply Chain. This Antenna had limited technical data, so stock samples were obtained. The data and samples were loaned to several companies that produce similar antennas. EDO Corporation and Dayton Granger provided the value engineering project team equipment specialist (ES) with a complete TDP which was forwarded to the Engineering Support Activity (ESA) for evaluation. The ESA disapproved both of these companies. Aviatech Corporation (Cooper Antennas) also contacted the ES in an effort to get approved. They submitted a complete TDP and the ES forwarded their proposal to the ESA. The ESA approved Aviatech and the ES updated the total item record and the contract technical data file. In the meantime, Atlantic Microwave became aware of the value engineering project team's attempt to increase competition and filed legal actions against Aviatech. Aviatech had previously submitted a quote for this item and based on the potential legal action decided to withdraw their quote. Aviatech then decided the legal action was just a threat and had their quote reinstated. Based on the VE study and results, and on the development of competition, Atlantic Microwave lowered their unit cost and received the contract. The unit cost was reduced 26 percent and over $10 million was saved through VE actions.

c. F/A-18 Shielding Gaskets

This VE project sought to develop gaskets to be used at attachment points for antennae on F/A-18 aircraft. The newly-developed gaskets serve as electrical conductors, sealants and corrosion-inhibitors, replacing the electrically conductive compound used in the original design application. The original design required inspections on short intervals since corrosion was a significant issue. With the new design, the length of the inspections intervals were increased significantly. Reduced maintenance and increased aircraft readiness resulted from the successful implementation of the new gasket designs. Total first year VE savings realized were $4.5 million, including both labor and materiel procurement savings.

d. Contingency Automation Application Trap

General Dynamics designed the Readiness/DVD Trap based on recommendations from a VE team. Customers submit Military Standard Requisitioning and Issue Procedure orders to be scanned by Defense Logistics Agency (DLA) Transaction Services. Orders meeting specific criteria are trapped and forwarded to the Contingency Automation

Application (CAA) Trap. CAA sources the "Readiness" orders to the Medical Directorate's array of Readiness Contracts. Non-Readiness orders are sourced to the Electronic Catalog (ECAT). In both cases, the customer is charged the cost recovery rate for the process used, e.g., 22 percent for Readiness Contacts, and 4 percent for ECAT instead of the ~50 percent for a traditional DVD buy. Orders that cannot be sourced are returned to Enterprise Business System via DLA Transaction Services. With the expansion of the Readiness Trap and the implementation of the DVD Trap, significantly more DLA customers receive orders within a three to ten-day range versus the thirty to ninety-days required for traditional DVD buys.

A quantity of 17,045 orders were processed to completion, resulting in cost recovery rate savings of $3.9 million. The Readiness/DVD Trap also allowed the re-allocation of approximately fourteen GS-12 contracting personnel, resulting in additional savings of $1.5 million.

4. Missile Defense Agency

a. Terminal High Altitude Area Defense (THAAD) Insensitive Munitions (IM) and Final Hazard Classification (FHC) Test Assets

A Cost Reduction Value Engineering Analysis was performed by a team to determine the most cost-effective alternative for conducting the Fast Cook-Off (FCO) Test. The FCO Test is a requirement for both IM and FHC compliance and is conducted using guidance from NATO Standard Agreement (STANAG) 4240. THAAD must satisfy the FHC requirements in Technical Bulletin 700-2 in order to receive approval for transportation of missile rounds to the continental United States and outside the continental United States deployment locations. The team determined that certain components were unnecessary for the tests and could be deleted from the Missile Round Pallet configuration. The VE proposal was completed and these components were deleted from the contract. The resultant VE savings totaled $42.1 million.

b. THAAD Missile Obsolescence

The X-Band Radar Signal/Data Processor Equipment utilized within the Army/Navy/Transportable Radar Surveillance-2 (AN/TYP-2) radars became obsolete, negatively impacting the continual requests for additional radar deployment around the world. Alternatives to purchasing "as new" assets were reviewed and, as a result of a Value Engineering Proposal (VEP), decommissioned Government Furnished Equipment was identified. The Federal Bureau of Investigation possessed nine Superdomes that could be transferred to the Missile Defense Agency. The VEP, therefore, enabled the accelerated production and fielding of a new radar that was required to meet warfighter requirements. The proposal also ensured that quantities of cost-effective radar

components and assemblies were available for effective support worldwide. This effort was a joint venture that included expertise between the X-Band Radars Project Office and the Army Research, Development, and Engineering Center. The total VE savings was $116.8 million.

5. Defense Intelligence Agency

a. Bulk Extractor Program

The Office of Technical Exploitation, National Media Exploitation Center, value team designed a high performance carving and extraction command line program (Bulk Extractor) that sequentially scans digital media and rapidly locates and extracts email addresses, credit card numbers, URLs, and other types of information used in forensic investigations. The Bulk Extractor program supports the warfighter by technical exploitation of captured enemy media, and is a force multiplier to special operations forces engaged in highly dangerous direct action missions in overseas contingency operations. Bulk Extractor facilitates the rapid processing and exploitation of material, which provides unique operational insight to our adversary's capabilities, intentions, and plans. Savings of $20 thousand per forensic examiner and over $100 thousand for a small forensic laboratory were achieved. In addition, efficiency and effectiveness increases reduced manual examination from twelve hours to four hours per case.

C. Concluding Comments

Many opportunities for VE savings exist in all aspects of DOD organizations and defense programs. While the examples here are formally recognized projects, numerous untapped opportunities are available to achieve savings and efficiencies if organized efforts are undertaken to identify appropriate candidates. These organized efforts will be more effective if all organizations name a VE proponent/focal point and pursue VE opportunities per guidance found in OMB Circular A-131.[8]

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[8] Office of Management and Budget, *Value Engineering*, Circular No. A-131, 21 May 1993 (available at http://www.whitehouse.gov/omb/circulars_a131).

3. VE over a System's Life Cycle

VE can be applied throughout the life cycle of a DOD system. Section A of this chapter describes the overall DOD Systems Acquisition Framework[9] and indicates areas with the greatest potential for achieving VE benefits. The remainder of the chapter provides specific VE opportunities during each phase of a system's life cycle in a systems engineering context. Section B discusses VE early in the life cycle. VE during production and deployment is covered in Section C. Finally, Section D illustrates VE in the Operations and Support (O&S) Phase.

A. Introduction

The Defense Acquisition Management Framework is characterized by five phases separated by three major milestone decision points, as depicted in Figure 3. The five phases are:

- Materiel Solution Analysis,
- Technology Development,
- Engineering and Manufacturing Development,
- Production and Deployment, and
- O&S.

The three major milestone decision points are:

- Milestone A which authorizes the Technology Development Phase;
- Milestone B which is typically the formal program initiation; and
- Milestone C which approves Low-Rate Initial Production.

The Material Development Decision does not approve a new acquisition program. It initiates an effort to identify and analyze alternatives for closing a capability gap. A successful Preliminary Design Review (PDR), conducted toward the end of the Technology Development Phase, signifies that there is high confidence that the design will be operationally effective and suitable. The Critical Design Review (CDR) assesses

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[9] See Department of Defense Directive 5000.01, "The Defense Acquisition System," 12 May 2003, and Department of Defense Instruction 5000.02, "Operation of the Defense Acquisition System," 8 December 2008 as updated by Directive-Type Memorandum (DTM) 09-027 – Implementation of the Weapon Systems Acquisition Reform Act of 2009.

the final design and its documentation is sufficient to begin manufacturing. The Full-Rate Production decision is made after the initial operational test and evaluation have been completed. Initial Operational Capability and Full Operational Capability are achieved as the production units are fielded.

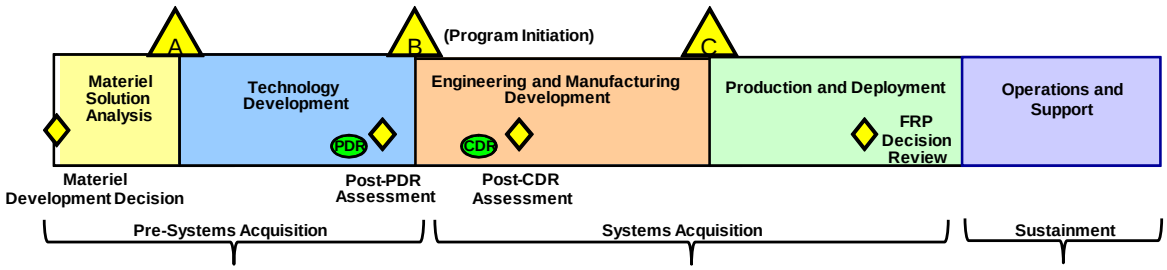
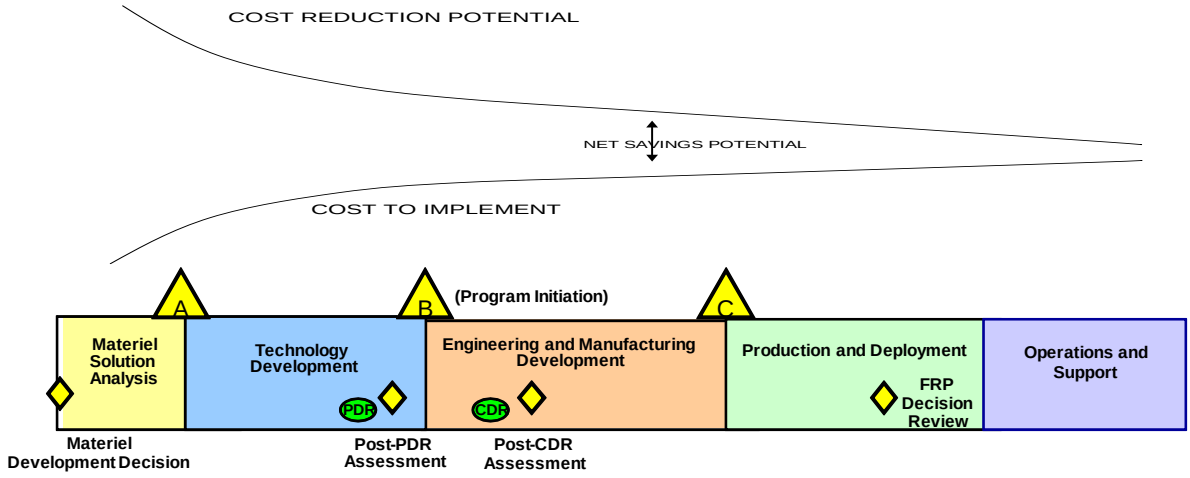


Figure 3. Defense Acquisition Management Framework

While value engineering is applicable at any point in the life cycle, Figure 4 shows that the savings potential commonly decreases as the program ages. VE should be applied as early as possible in the life cycle. Early VE tends to produce greater savings (or cost avoidance) because greater opportunities exist for change and the changes cost less to implement.

Even if early opportunities are missed, VE can still be applied. Late in a program VE is precluded only in those rare instances where the cost of the VE effort and subsequent implementation would be greater than the savings potential. While later VE normally adds implementation costs and affects smaller quantities, such deterrents are typically offset by improved performance and reliability through advances in technology and savings generated from increased product life.



Source: Adapted from E. D. Heller, General Dynamics Corporation.

Figure 4. VE Savings Potential During the Life of a Typical System

DOD Directive 5000.01 encourages cost savings: "Acquisition programs shall be managed though the application of a systems engineering approach that optimizes total system performance and minimizes total ownership costs."[10] The use of VE and the VE methodology can make valuable contributions to the systems engineering process throughout the life cycle, although the most appropriate time to apply VE varies. When to apply VE depends on whether:

- Current system performance or cost does not satisfy the customer;
- Advances in technology have system application, resulting in enhanced performance or reduced cost;
- The likely savings are high; or
- VE may be applied easily.

An important precursor for applying the VE methodology is properly establishing separate cost and income baselines and accumulation practices. This enables more accurate tracking of savings during execution. The following sections describe VE opportunities early in the life cycle, during production and deployment, and during operations and support.

[10] DOD Directive 5000.01, Paragraph E1.27.

B. VE Early in the Life Cycle

The most opportune time to apply the VE methodology is early in the life cycle, *before* production begins, *before* field or technical manuals are drafted, and *before* logistic support plans are finalized. Some of the more important benefits are as follows:

- Savings can be applied to all production units.
- Reductions to the high cost of development, the subsequent cost of production, and the consequent costs related to operation and support may be realized.
- Fewer modifications to production lines, tooling, processes, and procedures will be required.
- Fewer drawing changes will be necessary.
- Fewer post-production changes to logistic and support elements such as manuals, maintenance facilities, and spare parts requirements will be needed.

The Materiel Solution Analysis, Technology Development, and Engineering and Manufacturing Development Phases encompass the early part of the life cycle.

1. VE During Materiel Solution Analysis

Materiel Solution Analysis begins with the approval of an Initial Capabilities Document that identifies the needed capability. By this time, alternative materiel solutions for attaining the needed capability have been developed, and a plan for an Analysis of Alternatives (AoA) has been approved. The purposes of Materiel Solution Analysis are (1) to refine the initial options so that a decision on the preferred materiel solution can be made and (2) to develop a Technology Development Strategy for the preferred materiel solution. Materiel Solution Analysis presents the first substantial opportunity to influence system design by balancing technology opportunities, schedule constraints, funding availability, performance parameters, and operational requirements.

During Materiel Solution Analysis, systems engineering ideally provides top-level, iterative, and recursive analytical processes for each alternative under consideration. Such application of the systems engineering processes can result in a technical evaluation of the operational effectiveness and estimated life-cycle costs of the alternatives that may provide a materiel solution to a needed mission capability. Trade-offs among system operational requirements, operational utility, technology maturity, and life-cycle costs lead to a best system solution within allowed constraints. Effectively employing systems engineering will also support a preliminary assessment of the technical and technical management risk that will be considered in choosing the preferred materiel solution and formulating the Technology Development Strategy.

In the recent past, systems engineering has not had a significant impact this early in the life cycle. Initiatives are underway however to begin acquisition-related technical

planning earlier. The Assistant Secretary of Defense for Research and Engineering now serves as a technical advisor in the development of AoA study guidance to facilitate the consideration of technology and engineering risks for the alternatives under consideration.[11]

All such activities lead to a Systems Engineering Plan (SEP) at Milestone A. VE can have a significant role in support of the SEP during Materiel Solution Analysis. The AoA and associated cost-effectiveness studies[12] can use VE to analytically evaluate functions and provide a mechanism to analyze the essential requirements and develop possible alternatives offering improved value. In this context, evaluations of the technical requirements of each alternative are made and their effects on total performance determined. Concurrently, the effect on life-cycle cost of each alternative being considered is estimated and related to the technical requirements. Areas of high cost and high-cost sensitivity are identified, and the associated requirement is examined in relation to its contribution to system effectiveness. The requirements identified by these high-cost areas are examined for cost-effectiveness. Based on these efforts, the VE function may be used to do the following:

- Constructively challenge the stated needs and recommend alternatives,
- Constructively challenge the desired mission performance envelopes to ensure they are necessary and cost effective, and
- Ensure that user requirements are well founded.

2. VE During Technology Development

A successful Milestone A decision initiates the Technology Development Phase. This phase reduces technology risk and determines the appropriate set of critical subsystem technologies to be integrated into a full system. It is a continuous technology discovery and development process that reflects close collaboration between the science and technology community, the user, and the developer. Technology development is an iterative process of assessing technologies and refining user performance parameters. At the end of the Technology Development Phase, all critical technologies should have been demonstrated in a relevant environment at the system, subsystem, or prototype level.

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11 See Directive-Type Memorandum (DTM) 10-017 – Development Planning to Inform Materiel Development Decision (MDD) Reviews and Support Analyses of Alternatives (AoA).

12 Emerson N. Wells, "Cost Effectiveness and Value Engineering: A Comparative Analysis," *SAVE International Annual Conference Proceedings*, Volume III, Atlanta, Georgia, 15–17 April 1968, 47–55.

During technology development, systems engineering provides comprehensive, iterative processes to mature the suite of technologies for the preferred system solution by:

- Converting critical capabilities into subsystem performance specifications;
- Translating user-defined performance parameters into configured subsystems;
- Integrating the technical inputs of the entire design team;
- Managing interfaces;
- Characterizing and managing technical risk;
- Transitioning technology from the technology base into program-specific efforts;
- Defining the functional baseline;
- Developing preliminary designs; and
- Verifying that preliminary designs meet operational needs.

VE can be used to analyze the value of each requirement and the specifications derived from it by comparing function, cost, and worth. By critically examining the cost consequences of requirements and specifications, a VE study can generate answers to the following questions:

- Is the resultant cost effect of each requirement comparable to the worth gained?
- Is the resultant cost effect of the tolerance specified on each requirement comparable to the worth gained?
- Is its resultant cost effect upon the product comparable to the worth gained by the specification?
- Can the specification be tailored to minimize effort and cost?

Such an analysis can help determine whether user requirements and specifications are well founded and also lead to their relaxation or elimination in an effort to transition technology from the technology base into program-specific efforts. Once technology is mature enough to transition, the functional baseline can be refined. In this context, VE should be used to:

- Identify the necessary top-level functions for each of the missions considered,
- Identify technical approaches (i.e., design concept) to the missions,
- Identify necessary lower level functions for each technical approach (the value engineer should place emphasis on eliminating unnecessary design restrictive requirements),

- Evaluate each function in terms of technical feasibility, and
- Estimate the cost of various functions.

An effective application of the VE methodology will include further analysis of the high-cost functions and the identification of alternative, less costly ways of achieving the same result. When programs view life-cycle cost as an independent variable (CAIV), it should be treated as equally important to performance and schedule in program decisions. Program managers are encouraged to develop a formal CAIV plan as part of their acquisition strategy, which is required at Milestone B. While the implementation steps in a CAIV plan will depend on the type of system and its current stage in the acquisition framework, two of the suggested elements, cost goals and trade-off studies, tie closely to VE.[13]

Cost Goals. The CAIV plan would include cost goals for unit production cost and O&S costs. Typically, the unit production cost goal would be established for a specified quantity of systems and a specified peak production rate. The O&S cost goal would, typically, be an annual cost per deployable unit (e.g., battalion or squadron) or individual system (e.g., ship or missile). The goals should be challenging but realistically achievable.

Trade-off Studies. Cost, schedule, and performance may be traded off within the trade space between thresholds and objectives documented in the capability development document. Over time, as the system design matures, the trade studies become more refined and specialized.

3. VE During Engineering and Manufacturing Development

Formal program initiation usually occurs when the Milestone Decision Authority approves entrance into the Engineering and Manufacturing Development Phase. In this phase, the program, system architectures, and system elements down to the configuration item level are defined based on the technology matured during the Technology Development Phase. Preliminary designs and the support concept are refined and integration and manufacturing risk are reduced.

The Engineering and Manufacturing Development Phase is divided into two parts: Integrated System Design and System Capability and Manufacturing Process Demonstration. During Integrated System Design, systems engineering reduces technical risk, identifies potential technical management issues, and guides detailed design choices by allocating requirements at greater levels of detail. Through the use of systems engineering, the System Capability and Manufacturing Process Demonstration effort

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[13] See “Defense Acquisition Guidebook,” Section 3.2.4, Cost As an Independent Variable, https://acc.dau.mil/CommunityBrowser.aspx?id=314768#3.2.4.

demonstrates the system performance in its intended environment. Test units are built to verify that specified requirements have been fulfilled at each step. Validation at the end of the process confirms that user needs are met.

As part of detailed design, VE should support the system engineering process by helping to develop alternative ways of providing the required function with lower production and sustainment costs. The value engineer usually engages in such activities in high leverage areas. Therefore, the VE process should first identify individual high-cost subsystems or items to stimulate early detection of unnecessary costs in time to take corrective action. Once these high-leverage areas have been determined, the next step is to shape and evaluate alternative designs in relation to the technical requirements, performance limits, subsystem interrelationships, logistics support requirements, and system cost and value. VE contributes to sustainability planning as it is used to establish maintenance plans and to ensure that the design process incorporates logistic requirements and cost considerations, including reliability, maintainability, spares, and obsolescence.

Common VE activities include the following:

- Evaluating design concepts from a life-cycle cost standpoint,
- Eliminating unnecessary design-restrictive requirements established by the user or design community,
- Achieving CAIV goals,
- Meeting system requirements at the lowest life-cycle cost,
- Searching for new manufacturing processes or new materials to be used in the design,
- Searching for problems encountered by others who attempted to design similar systems or components,
- Defining interfaces between or among functional areas, and
- Conducting design trades.

During System Capability and Manufacturing Process Demonstration, VE challenges the need for expenditures on data, number of prototypes, peculiar support equipment, and so on. Initial prototypes are evaluated to identify additional opportunities to improve value. VE efforts at this stage analyze how suppliers can help reduce costs by asking the following questions:

- Have suggestions been invited from prospective suppliers regarding possible value improvement from loosening specification requirements?
- Have all nonstandard parts been identified and approved?

- Can the use of each nonstandard part be adequately justified?
- Can a redesign replace a nonstandard part with a standard part?
- Are the standard circuits, standard components, and standard hardware the lowest cost items that will supply the minimum required characteristics?

Once models and prototypes are built, they must be verified to meet the requirements. VE also supports this testing process by:

- Identifying functions to be tested;
- Challenging the need for certain tests based on the functions the tests are designed to serve;
- Challenging the tolerances of the tests specified, based on the functions the tests are designed to serve; and
- Determining cost-effective ways to test them.

Finally, as a result of the testing experience, the VE process should look for opportunities to simplify the design for operational use—make the system easier to operate and maintain. Once production begins and the system is fielded, it becomes much more expensive to make these kinds of changes.

C. VE During Production and Deployment

The Production and Deployment Phase begins at Milestone C. During this phase, the system achieves operational capability to satisfy mission needs. As the integrated components develop into a system, the test and evaluation processes frequently reveal issues that require system improvements or redesign. When the testing environment more closely resembles actual field conditions, the required improvements may be complex and subtle. The initial manufacturing process may also reveal unanticipated problems that may be resolved by changing the product somewhat. Low-Rate Initial Production should result in the completion of manufacturing development. Full-Rate Production delivers the fully funded quantity of systems and supporting materiel and services for the program or increment.

Systems engineering in the Production and Deployment Phase is primarily concerned with analyzing known deficiencies and determining corrective actions. A plan to build, modify, verify, and test the proposed solution is also formulated and approved. The proposed solution to the deficiency is translated to the appropriate hardware, software, or specification changes. Modifications are created, incorporated, and verified in accordance with the approved plan. This product change may include retrofitting, since the production process has begun. The impact on system cost, schedules, and performance should also be considered when addressing production incorporation.

VE contributes to these systems engineering activities by devising alternatives to achieve the required functions and developing alternative designs to meet functional needs. VE has been extensively applied to evaluate and improve manufacturing processes, methods, and materials. These include support equipment, technical data, and facilities, as well as the supply, transportation and handling, maintenance, and training functions. High leverage opportunities for VE projects often occur when:

- Recent developments indicate a potential opportunity for cost reduction;
- The future use of the item depends on significant reduction in production costs; and
- New manufacturing technology and new materials become available.

In addition, as production becomes more mature, VE may support the decision to eliminate quality assurance testing, which often cannot be proposed until considerable experience is acquired and data gathered to prove that it is feasible. VE may also reveal that the management reports required to understand a complex situation early in production may turn out to be unnecessary after more experience is gained.

D. VE During Operations and Support

During the O&S Phase of the acquisition framework, system support is provided to satisfy operational requirements and sustainment needs in the most cost-effective manner over the life cycle. Usage data are collected and analyzed to determine the root cause of any problems encountered. After a risk assessment is conducted, corrective actions are formulated.

In this phase, systems engineering processes support in-service reviews; trade studies; and decisions made about modifications, upgrades, and future increments of the system. Interoperability or technology improvements, parts or manufacturing obsolescence, aging issues, premature failures, changes in fuel or lubricants, Joint or Service commonality, and so on may all indicate the need for a system upgrade. System disposal is not a systems engineering activity, but systems engineering processes that inject disposal requirements and considerations into the earlier design processes ultimately affect disposal.

After fielding, opportunities for VE may exist for a long time. Product life cycles are being extended; for consumables, there is no sure way to determine the total quantity that will be purchased. Also, in the past, many items that entered the defense inventory were never subjected to a VE analysis. The potential for VE savings on these items is real. Advances in technology or changes in user requirements provide a basis for potential savings.

After a system or item is fielded, changes are often expensive to implement. The potential for large savings to the operation, maintenance, and other logistics functions, however, might justify the investment. Using VE principles supports the development, evaluation, and implementation of such changes within the overall systems engineering processes. Within the Defense Department, the following activities have proven to be a successful context for VE:

1. Establish cost consciousness in the program
2. Establish a cost baseline and identify cost drivers
3. Develop a cost-reduction strategy
4. Manage cost within the program
5. Establish cost goals, objectives, and thresholds
    a. Establish meaningful cost-reduction metrics
    b. Identify and quantify cost-reduction initiatives
    c. Track implementation of cost-reduction projects
    d. Measure results against the plan

VE contributes to every aspect of those activities; it is especially suited to the identification and evaluation of cost-reduction initiatives. The evaluation function is extremely important because these initiatives typically include an up-front investment that will be recouped over time.

VE has been used to formulate initiatives to:

- Extend item life by applying state-of-the-art designs, materials, or unit processes;
- Reduce repair costs by achieving the repair function in a more economical manner;
- Reduce packaging costs by improving packaging procedures or materials;
- Remanufacture and replace legacy systems;
- Improve reliability and maintainability;
- Use commercial unit processes, technologies, and commercial off-the-shelf items to reduce cost and improve reliability;
- Replace aging engines and engine parts;
- Improve supply-chain response time and reduce logistics footprint using Direct Vendor Delivery, Commercial Maintenance Agreements, and Virtual Prime Vendor support;

- Initiate reliability-centered maintenance and condition-based maintenance to reduce preventive maintenance costs without affecting corrective maintenance needs;
- Reduce the number of people required to operate and maintain by improving usability and maintainability; and
- Eliminate sole-source procurement.

E. Concluding Comments

A detailed understanding of the acquisition management framework is not a prerequisite for applying VE. It is presented here to describe how VE is likely to be applied throughout a system's life cycle and to emphasize that the earlier VE is applied, the greater the potential for savings. A common misconception is that VE applies only to production contracts. Whenever a new development contract is awarded, the contractor's systems engineering processes lead to trade-offs to meet the cost and schedule requirements of the contract. Even under circumstances with exceptionally low risk, a parallel effort to investigate using an alternative (emerging) technology that is expected to perform better at less cost is usually not possible because of constraints on time or resources. Resources for conducting such parallel efforts can be made available by exercising the VE clause in government contracts, as long as the Government is satisfied that the original solution was the best available at that time. Finally, in the current acquisition environment, many systems remain in inventory for a long time because of major modifications or upgrades (e.g., block changes or preplanned product improvements). As a result, opportunities for large VE savings extend much later into the life cycle.

4. The Application of Value Engineering to a Construction Project

A. Introduction

This chapter discusses VE's application during the three main phases of a construction project – Planning, Design, and Construction. VE can be applied at any point in a construction project, even during actual construction. Typically the earlier it is applied, however, the higher the return on the time and effort invested. Benefits include:

- Improved functionality of the project—a "second look" at the design produced by the architect and engineers assures that all reasonable alternatives have been explored;
- Significant savings—both during construction and over the life cycle;
- More reliable cost estimates and scope statements—both are checked thoroughly assuring that nothing has been omitted or underestimated; and consequently
- Best value will be obtained over the life of the building.[14]

As a general rule, no constraints are placed on the VE program in terms of areas of study for projects. Likewise, governing criteria, except as required by codes or law, are considered open for challenge by VE providing that the value and cost benefits are worthwhile and no compromises are made to important project functions. Even the requirements for a project are open to challenge by the VE team, to the extent that programmatic inefficiencies can be eliminated without sacrificing the basic project objectives and intended features or functions of the completed facility.

For a specific project, any constraints placed on the study must be identified and justified prior to starting the VE study. Such constraints are uncommon and are, generally, the result of specific studies produced by the architecture and engineering (A/E) firm or other consultants and not the result of the normal design process.

Conversely, the VE team is expected to use common sense when challenging design decisions or criteria that are deep seated and important issues to the A/E firm or the agency user. This should also preclude the team from spending valuable time on farfetched or frivolous ideas that have little or no chance of acceptance. The U.S. Army

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[14] *Whole Building Design Guide*, National Institute of Building Sciences, 1090 Vermont Avenue, NW, Suite 700, Washington, D.C. 20005-4950.

Corps of Engineers (USACE)[15] and the Naval Facilities Engineering Command (NAVFAC)[16] have detailed guidance for executing in-house VEPs and VECPs. The USACE and NAVFAC references provide specific VE program instructions for their respective organizations. In addition to USACE and NAVFAC VE guidance, the General Services Administration has published a VE guide that is also a useful source of information on establishing a VE program.[17]

The next section of this chapter describes the charrette process and its relationship to VE. Sections D, E, and F describe, in general terms, how to apply VE methodology in each phase of a construction project.

B. Charrette Process

A charrette is a meeting where participants work together intensely to find a solution to a problem or resolve an issue within a specified time limit. It is applicable to military and civil works construction projects. USACE and NAVFAC both have guidelines for applying the charrette process. A charrette can occur at any time, but preparation is crucial. Goals must be clear so the expectations do not exceed possible results. The sponsoring agency usually sets the goals and time limit and announces them ahead of time. The broad backgrounds of participants assures full discussion of issues, interrelationships, and impacts. Its time limits challenge people to examine the problem rapidly, openly, and honestly and help potential adversaries reach consensus on an appropriate solution.

A charrette sharpens agency understanding of the perspectives of interest groups. A charette is often used early in a planning process to provide useful ideas and perspectives from concerned stakeholders. In the design phase, a charrette helps resolve controversial issues. In the construction phase it is useful to resolve an impasse between the user and contractor and in the case of civil works projects, community groups, and the government. A charrette may enlarge the degree of public involvement in civil works projects, reducing feelings of alienation from government.

A charrette combines effectively with VE techniques. Charrettes generate alternative solutions to problems. The setting encourages openness and creativity. All suggestions from the group–however outrageous–should be examined to encourage thinking about better approaches. Anyone can participate in a charrette.

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15 Army Corps of Engineers, Engineers Regulations (ER) 11-1-321, Change 1, *Army Programs Value Engineering*, 1 Jan 2011.

16 Naval Facilities Engineering Command (NAVFAC), *Value Engineering Process Templates and Instructions*, 11 Jan 2011 (Draft).

17 U.S. General Services Administration Public Buildings Service, *Value Engineering Program Guide for Design and Construction, Volume 1, Internal Operations and Management*, Dec 1992.

C. VE during the Planning Phase of a Construction Project

During the planning phase, VE can make a major impact on the life-cycle cost (LCC) of a construction project. LCC includes the cost of planning, design, construction and ownership of a project over a specified length of time. The time period used is the projected effective useful life of the project and its determination includes consideration of functional obsolescence of major components or systems. LCC is used to compare and evaluate the total costs of competing solutions.

In addition, adjustments to the program at this point have very little if any disruptive impact on schedule, A/E time, and redesign costs. Consequently, the project should proceed with fewer changes and with a greater understanding by all parties of what the final function and space allocations will be. During the planning phase an independent VE team should:

- Review the program,
- Perform a functional analysis of the facility,
- Obtain the owner/user's definition of value,
- Define the key criteria and objectives for the project,
- Verify/validate the proposed program,
- Review master plan utility options (e.g., Central Utility Plant versus individual systems),
- Offer alternative solutions (square footage needs per function, adjacency solutions, etc.), and
- Verify if the budget is adequate for the developed program.

Significant benefits may also be derived from bringing in an independent VE team to provide an outside view of alternate solutions from other similar projects. Organizations may employ both VE and charrette processes to improve design and resolve issues. Paired with the VE process, a charrette is an attractive means of eliciting ideas and resolving issues. A VE brainstorming session may raise several issues. A charrette can be used to focus on a single issue raised during a VE brainstorming session.

D. VE during the Design Phase of a Construction Project

VE is mostly often used when the design is in the schematic stage, i.e., the architecture drawings are developed enough to include the major components, such as elevation, electrical, mechanical, etc. By this time typically 35 percent of the design has been completed. DOD agencies should conduct at least one VE workshop on projects that cost $1.0 million or more. The workshop is an opportunity to bring the design team and client together to review the proposed design solutions, the cost estimate, and the

proposed implementation schedule and approach, with to the goal of implementing the best value for the money. The definition of what is good value on any particular project will change from client to client and project to project. Generally, workshop activities include the following:

- Obtain all necessary information from the best possible sources;
- Determine and evaluate the functions of the present design;
- Obtain costs and determine present design constraints;
- Answer the questions – what is it? what does it do? what must it do? and what does it cost?
- Use brainstorming to develop creative alternative designs that meet the required functions;
- Make sketches;
- Consult experts and use judgment;
- Answer the questions – what does each feasible alternative cost and will each perform the basic function(s); and
- Recommend specific design alternatives.

Charrette workshops focusing on design issues use VE techniques during the conceptual phases to help develop conceptual designs that respond to project scope, budget and technical issues. The Request for Proposal (RFP) acquisition strategy for design-build projects use charrettes to allow project users to work closely with the designers to improve their understanding of all of the project functional requirements and the related design and project issues. The goal of the charrette is to use the knowledge, experience, and creativity of the RFP Design Team to challenge and improve the initial conceptual design and to insure that all functional requirements for the new facility are addressed in the RFP.[18]

E. VE during the Construction Phase of a Construction Project

During the construction phase, VE improvements are still possible using VECPs. A VECP is submitted by the construction or design-build contractor to propose a change or substitution in the requirements, materials and/or methods prescribed in the contract documents. The change is intended to reduce cost (both initial and/or life-cycle) but still meet or exceed all necessary functions including performance, safety, aesthetics, operations, and quality. Quite often a contractor can provide a fresh approach to construction that can reduce the cost of facilities and at the same time improve the

[18] NAVFAC, *Value Engineering Process Templates and Instructions*, 11 Jan 2011 (Draft).

construction sequences and reduce time on the job. The objective of the VECP program is to encourage contractors to investigate improved construction methods and materials, submit VECPs and, upon acceptance, receive fair and reasonable compensation in the way of shared savings. Construction contracts encourage the contractor to have a VE clause in any subcontracts totaling $65,000 or more.

Clearly the DOD user must consider contractor-generated proposals very carefully, from a life-cycle and a liability perspective. The A/E team must be brought into the decision making to agree that the proposed change will not have any negative impact on the overall design and building function. The evaluation of a VECP is treated similarly to any change order during construction, with issues such as the impact on the schedule and productivity being considered along with the perceived cost savings generated. A more detailed discussion of VECPs is contained in Chapter 7 of this handbook.

F. Concluding Comments

VE is not a design/peer review or a cost-cutting exercise. The objectives of any VE study must be consistent with the overall philosophy and objectives of the program, and the individual requirements of the project. If the construction cost for a project is within budget, the emphasis will be on maintaining or improving value in terms of operations, flexibility, expandability, etc. If this can be delivered at reduced cost, then cost/budget reduction becomes a secondary goal. When a project is above budget, the emphasis of the VE study will be on reducing construction cost to be within budget without compromising requirements or eroding the value of the finished project. *The VE study is not intended to be used as a device for producing cost reductions by "cost cutting" with an accompanying reduction in the scope or value of the project over the life cycle of the completed facility.*

5. Introduction to the VE Methodology

This chapter provides an introduction to the value methodology (or job plan)[19] as it is used to develop recommendations and implement solutions for an identified problem. Section A summarizes the job plan phases. Because working with people is a large component of the value methodology, understanding social dynamics and the problems that may be encountered in a VE project is important. Section B discusses some of these problems and offers potential solutions. Proper project selection is also critical to the success of the VE study; Section C illustrates how the job plan may be used solely within that context.

A. Job Plan Summary

The VE job plan breaks out the VE project being studied into functions. It provides time for the essential creative work and its necessary analysis so that the best choices can be made for further development. The job plan leads to the establishment of an effective program to select the best value alternative. It concludes with specific recommendations, the necessary data supporting them, a list of implementing actions, a proposed implementation schedule, and a required follow-up procedure.

The job plan is normally organized by a value team leader. It is typically conducted in eight sequential phases (which may overlap in practice):[20]

1. Orientation Phase
2. Information Phase
3. Function Analysis Phase
4. Creative Phase
5. Evaluation Phase
6. Development Phase
7. Presentation Phase
8. Implementation Phase

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19 Value methodology, value engineering methodology and job plan are synonymous terms.

20 The structure of the job plan is adapted from *Value Standard and Body Of Knowledge*, SAVE International, June 2007. The SAVE International is devoted to the advancement and promotion of the value methodology. Information can be found at http://www.value-eng.org/.

The Orientation Phase is conducted to prepare for the value analysis. This phase, which may last several weeks, lays the groundwork for an efficient and productive study by refining the problem statement, collecting much of the data needed, and organizing for the efforts to follow.

The value study comprises Phases 2 through 7 of the job plan. These are the more analytical steps in the value methodology, the phases typically performed in a workshop setting involving all stakeholders. Systematic pursuit of the analytical steps within these phases leads to recommendations for improving the existing situation and increasing value for everyone involved. They conclude with a presentation of recommendations for improvement to the decision-maker.

Conducting a VE workshop generally requires additional effort since workshops involve all stakeholders and may last five days. The first step in determining whether a workshop is needed is obtaining answers to the following three questions during the Orientation Phase.

1. What is the problem/opportunity/issue?
2. Why does the person/group think that it is a problem/opportunity/issue?
3. Why is a solution/resolution necessary?

After these questions have been answered satisfactorily, the criteria below help determine whether a workshop or an individual study is necessary to treat the situation.

- How many serious stakeholders? (five or more lead to a workshop)
- Are there diverse views among the stakeholders? (yes leads to a workshop, no leads to an individual study.)
- What is the importance of a resolution to the leader/organization? (low leads to an individual study, high could lead either way.)
- Can/will all stakeholders participate? (This can be fallout from bullets 2 and 3. If everyone cannot get together, a study leader may need to do a lot of communication without the benefit of a workshop environment.)
- What resources are available to conduct the workshop? (If a good workshop cannot be conducted with resources available, it is better not to start.)
- How many organizations are impacted? (At least three organizations lead to a workshop, less leads to an individual study.)
- What are the constraints on the solution and how rigid are they? (If rigid constraints force a decision to three or fewer “obvious” alternatives, it leads away from a workshop.)

- What information is available or missing? (This is situational. A lot of information or missing information that all leads to a single solution leads to an individual study. A lot of information or missing information that requires consensus leads to a workshop.)
- Is the technology part of the issue? If so, what is the maturity of the technology? (Developing new technology leads to a workshop, mature technology leads to an individual study.)

The Implementation Phase occurs after the value study is completed and decisions have been made. It monitors the approval process and implementation of the action plan. The name of the phase may be slightly misleading. Project approval is normally not given solely on the basis of the brief presentation that occurs at the conclusion of the workshop. Approval will usually be obtained after the completion of follow-up actions such as providing more data and meeting with others. Implementation itself begins after the final approval is granted.

Figure 5 depicts each phase of the job plan. It lists the questions that each phase is designed to answer and identifies the activities performed. This chart is discussed in detail in Chapter 6, where each phase is described.

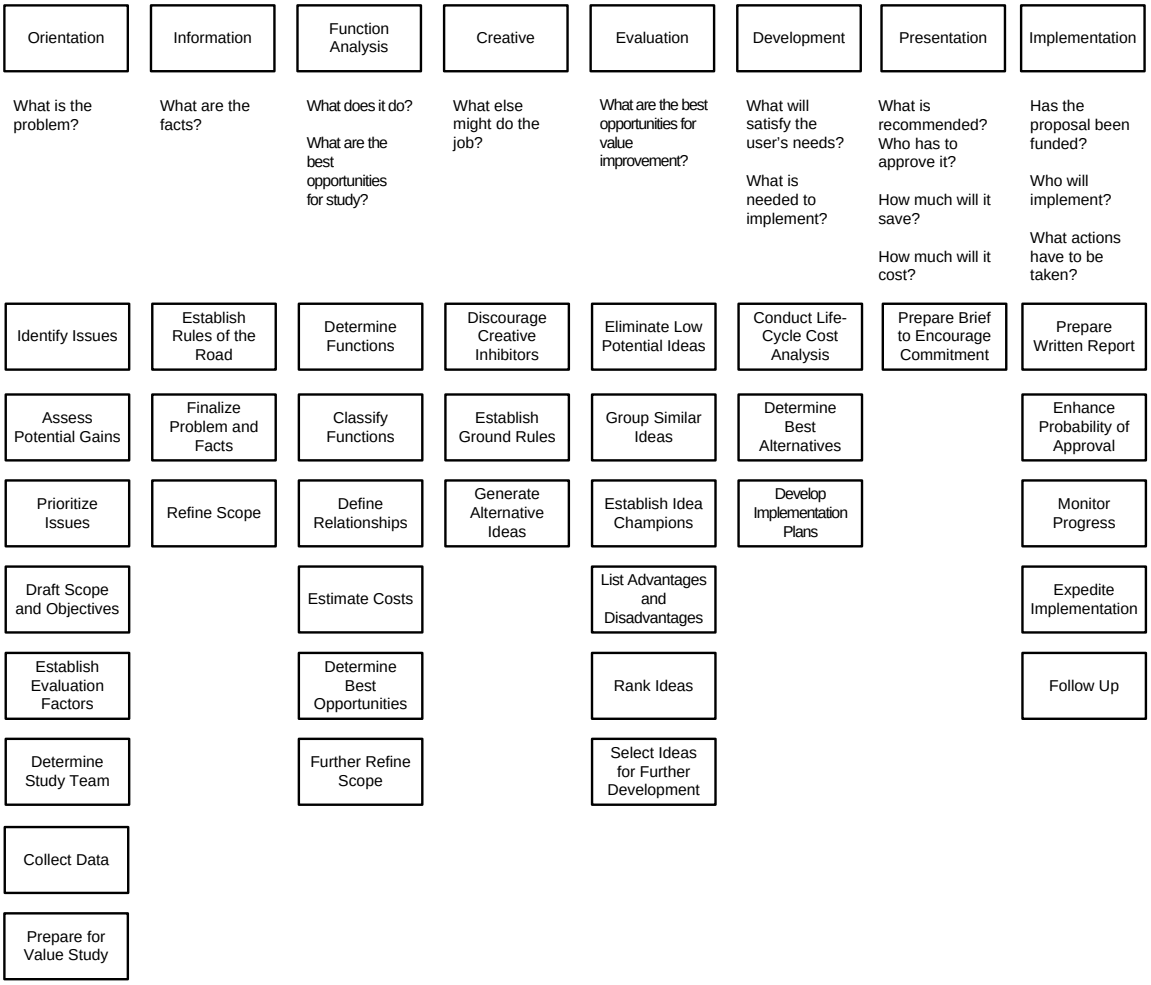

Figure 5. Depiction of VE Job Plan Phases

Although the job plan divides the study into a distinct set of work elements, judgment is necessary to determine the depth to which each phase is performed as a function of the resources available and the results expected. The VE program in the Defense Department does not necessarily use all the steps of the job plan. In fact, the only requirement for the Federal Government is that a change made to improve the value (i.e., performance and/or cost) of a required function be based on a function analysis to determine the best value. For example, an activity supporting the DOD component Breakout, Competition, or Spares Management initiatives may be a relevant use of VE. From a contractor perspective, any analysis leading to an approved VECP is applicable.[21]

[21] Department of Defense Inspector General, "DoD IG Issue Resolution Agreement: Defining Value Engineering (VE) for Reporting Purposes," 22 November 2000.

B. Preparing for the Social Dynamics in a VE Study

The concept of teaming has always been important in value engineering. In the 1980s, businesses began to look for improved ways of developing products to reduce the amount of "rework" necessary and to shorten the cycle time needed to get products to market. They began by organizing cross-functional teams comprised of the various disciplines involved and gave the teams authority to develop the entire product. This change was important because when expertise resides in separate parts of the organization, all aspects of the effort are generally conducted sequentially. For example, a requirement for a new product might start with a concept group, then be given to a design group, a test group, and finally to a manufacturing group before the product ever gets to market. If the design group provides a prototype to the test group and they discover flaws in the details, it must be sent back to the design group for alteration resulting in delays and duplicative effort. Using cross-functional teams, on the other hand, means that expertise from various disciplines is used in a single organization with full authority to design, develop, test, manufacture, and deliver a product. Today, the concept of teaming has become the way leading-edge firms in the private sector and in Federal agencies perform many multi-disciplined projects.

Consequently, a prime factor in the success or failure of a study is how VE team members conduct themselves in various situations:

- Contacts between members of the VE team) and their sources of information (e.g., design engineers, estimators, and users),
- Relations within the VE team, and
- Contacts with persons who have the authority to approve or disapprove the changes recommended by the VE team.

"People problems" are sometimes more difficult to resolve than technical problems. Many of the people problems encountered in a VE study are motivated by a resistance to change. In the VE context, Donald E. Parker defines a "roadblock" as "a decision, attitude, or situation which inhibits progress."[22] Roadblocks are natural hazards to the benefits that would flow from VE changes, and both VE practitioners and managers must be able to deal with them effectively. Any change can meet resistance. Understanding why roadblocks occur and responding diplomatically with the facts will go a long way toward developing a solution. A roadblock or resistance to change has many sources:

- If the nature and effect of a proposed change are not clearly explained, and understood, it may be considered a threat. Incomplete information produces insecurity, and insecurity can turn to hostility.

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[22] Donald E. Parker, *Value Engineering Theory*, The Lawrence D. Miles Value Foundation, Washington, D.C., 1998, revised edition, 56.

- Different people interpret proposals in different ways, particularly if the suggestions are vague and not buttressed by adequate facts.
- When pressure both for and against change are intense, resistance grows, ultimately immobilizing everyone.
- The less opportunity individuals have to express their views about a proposed change, the greater their resistance to it.
- Proposals that are made on a personal basis, or that reflect on an individual's ability or performance, produce hostility.
- Strong resistance can be expected if a change will alter long-established institutions, habits, or customs.

Roadblocks can be easily recognized. In their most common form, they take shape as verbal barriers, either objective or emotional. These verbal barriers are then followed by a lack of cooperation. In the minds of people using them, roadblocks are self-justifying and do not require further explanation.

For a VE project to be successful, people from all levels in an organization must cooperate to develop a dynamic and creative spirit. Favorable attitudes toward and acceptance of a new concept are based upon positive individual experiences building upon one another over a period of time. Team members can use the following general principles of social behavior, adapted from Parker,[23] to promote cooperation in overcoming roadblocks and thereby gaining enthusiastic acceptance of VE:

- *Avoid blame for the current situation.* Recognize that something considered of poor value today may not have been considered as such when the decision to pursue it was made. Realize that the reasons for poor value are many, but the stigma attached to it can be minimized by understanding some of its causes, such as lack of information or time, habitual thinking, negative attitudes, reluctance to seek advice, improved technology, lack of understanding of real requirements, and lack of yardsticks to measure value.
- *Maintain openness throughout the project.* Acquaint people with the nature and objectives of the project. Make suggestions, recommendations, and requests clear at all times. Make the report clear and accurate. Always have facts to back up the proposal, and be prepared to present them clearly.
- *Avoid displaying a superior attitude.* When seeking information and assistance, honestly admit unfamiliarity with the item or project under study and express

[23] Ibid., 49–63.

appreciation for help provided. Show respect for another person's opinions. Never criticize or belittle a person's work on an item under study.

- *Be respectful.* Respect the chain of authority, customs of the organizations, and personalities of the people involved.
- *Maintain flexibility.* Assume someone else's role to ascertain the answers to the following questions: What do they say? What do their actions indicate? What do they really believe? Why do they believe this way, act as they do, or say what they say? Objectively select a workable approach to whatever attitude is encountered.
- *Consult with those affected by proposed changes.* Present proposals objectively and courteously. Avoid implied criticism. Anticipate the impacts on particular individuals and assess their potential reactions in advance. Listen to what they say and respond to their thoughts and needs. Continued objections to a proposal may be clues to modifications necessary to facilitate approval.
- *Make everyone part of the solution.* Give broad credit for contributions to a successful VE study. Convince all people involved that their competencies are recognized and essential to the success of VE studies and changes. Promote VE as a team effort of the entire organization.
- *Think positively.* Positive thinking has been suggested as an effective means of overcoming the natural fear of change.

Having a favorable setting and an effective facilitator for the value study helps relieve potential social dynamics problems. Holding the workshop away from the regular work environment is preferable because it:

- Ensures the full attention of the team throughout the scheduled study;
- Establishes a neutral setting where no stakeholder element can be perceived to have an advantage over another element;
- Creates a relaxed climate for communication;
- Reduces distractions; and
- Maintains focus and momentum.

Typically, the workshop is led by a facilitator, not the team leader. During a workshop, the facilitator should be able to contribute to all phases of the job plan as necessary without dominating the process. In the workshop context, the facilitator is responsible for:

- Presenting the problem at the start of the workshop;
- Keeping the team focused on the specific topic;

- Keeping all team members involved in the discussion and the work that needs to be done;
- Keeping the team moving and motivated;
- Leading the team effectively by delegating responsibilities as appropriate, maintaining neutrality, and being diplomatic;
- Maintaining enthusiasm for the VE study; and
- Communicating with the study sponsor.

The benefits of the VE methodology may be diminished in practice if the facilitator cannot deal effectively with difficult people on the team. Rae Gordon Cook discusses some of the top difficulties reported anecdotally for facilitators and suggests techniques for dealing with such situations.[24]

C. Using the Value Methodology to Determine the Right Problem to Attack

In some cases, defining the "right problem" can be a labor-intensive, time-consuming, and difficult task, and there is no guarantee that the result will be the best opportunity for value improvement. The value methodology itself can be applied to refine the problem-definition process, reduce the workload, and provide a greater likelihood of success.

Howard Greenfield describes a procedure for applying the value methodology to develop a new design concept (i.e., the "right project") rather than the traditional use of VE to optimize an existing design. VE techniques are iteratively inserted into the planning process to select a concept that delivers the optimum life-cycle cost. The following example illustrates how the job plan might be used in the broader problem-definition context.[25]

> Assume that a weapon system program manager is faced with high O&S costs that are diverting resources from important modernization needs. The program manager decides to use the value methodology to solve this problem by determining those O&S cost elements that are best addressed in greater detail. Table 1 shows the expected accomplishments in each phase of the problem definition job plan.

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[24] Rae Gordon Cook, "Tactics for Tough Facilitations: Dealing with Difficult People and Going International," *SAVE International Annual Conference Proceedings*, Volume XXXIII, Washington, D.C., 14–17 June 1998, 56–64.

[25] Howard Greenfield, "Integrating VE in Project Planning," *SAVE International 44th Annual Conference Proceedings*, Montreal, Quebec, 12–15 July 2004.

Table 1. Accomplishments by Job Plan Phase

Job Plan Phase	Accomplishment
Information Phase	Identify key cost drivers
Function Analysis Phase	Determine the high-level basic functions for each of the key cost drivers
Creative Phase	Generate ideas for strategies/approaches for attacking the functions that offer the greatest opportunity for value improvement
Evaluation Phase	Evaluate the alternative opportunities for value improvement for each of the key cost drivers
Development Phase	Refine the alternatives further, showing strengths and weaknesses
Presentation Phase	Show recommendations for further analysis to the study sponsor
Implementation Phase	Conduct a value study on the cost drivers selected for further analysis

Greenfield suggests that his procedure has the following advantages:

- Obtains early consensus on requirements to be fulfilled by the project,
- Allows groups with different interests and backgrounds to focus on the requirements of the specific project,
- Allows tough decisions to be made efficiently and promotes buy-in from stakeholders, and
- Reduces the time required to obtain the optimal solution.

These advantages also apply when using the value methodology to help identify the right problem to be addressed.

When dealing with a process, the following questions should be asked to determine if it is appropriate for a VE study.[26]

1. **Is it a process?**
   - Does it currently exist in the organization?
   - Can it be flow charted?

   If NO to either question – it is not a process!

[26] Adapted from the Government Assistance Program at the Egan Urban Center, DePaul University, Chicago, Illinois.

2. **Does the process recycle frequently?**
   - Is there less than one month between the first step and the last step?
   - Does the process recur several times in a day or week or every month?

   If NO to either question – it is not an appropriate subject for study!

3. **Can the process be measured easily?**
   - Is there a paper trail that follows the process?
   - Is there an observable beginning and end to the process that can be detected and measured?

   If NO to either question – there will not be sufficient information or data for the study!

4. **Is the process currently undergoing transition?**
   - Has another group been assigned to work on the process?
   - Will another group be assigned to work on it?

   If YES to either question – it is not appropriate for study at this time!

D. Concluding Comments

The VE job plan can be applied to any subject to guide a VE study from inception to conclusion. By adhering to certain procedures, the VE job plan ensures that consideration is given to all necessary facets of the problem. Although the job plan divides the VE study into a distinct set of work elements, judgment is necessary to determine the depth to which each phase is performed as a function of the resources available, the results expected, and the people involved (often the most important determinant).

6. The VE Methodology in Detail

Each phase of the job plan introduced in Chapter 5 and summarized in Figure 5 is divided into activities (or steps) that are described in the sections of this chapter.

A. Orientation Phase

The Orientation Phase refines the problem statement and prepares for the workshop. The value study and workshop have a greater likelihood of success if ample preparation time has been devoted to determining what aspects of the problem will be addressed in detail and preparing everything needed for the analysis. Throughout these preparatory activities, a close working relationship between the study team leader and the manager sponsoring the VE project contributes significantly to a successful outcome.

The following subsections describe the activities during the Orientation Phase. The activities can occur in an order different from that shown here. Some activities can also be repeated or occur simultaneously if other people are supporting the team leader's efforts.

The first five activities represent one systematic approach to refining the problem statement. The job plan can also be used entirely in the context of the Orientation Phase as a formal project planning tool. This is illustrated in Chapter 5, Section C.

1. Identify the Specific Issues To Be Addressed

The first step in a project is to identify a problem. The problem area should be divided into its constituent elements. Each element should represent a specific issue that can be addressed and resolved.

Consider, for example, the Navy's Standard Missile program. Missile demand was level but the price was increasing while budgets were decreasing. Of the three controllable constituent elements of missile cost (production, development, and logistics), production costs were determined by the program office to be the most fruitful area for further investigation. In fact, the production costs could readily be broken down into smaller and smaller constituent elements to form the basis of individual VE projects.[27]

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[27] See Roland Blocksom, "STANDARD Missile Value Engineering (VE) Program—A Best Practices Role Model," *Defense AT&L Magazine*, July–August 2004, 41–45.

Identifying specific issues is accomplished by developing an understanding of the sponsor's problems and avoiding areas that the sponsor would not be able change because of political, cultural, or feasibility implications. Once the problems are understood, they can be addressed at varying levels of detail. At this stage of the VE methodology, an adequate amount of detail is needed to obtain a general grasp of potential VE projects for the issue under consideration.

2. Assess the Potential Gains for Resolving Each of These Issues

The purpose of this activity is to identify issues that have the greatest potential for value improvement. Solution areas postulated this early should be used only for this step because they could inhibit creative activities used later in the job plan to generate alternatives.

The assessment of the potential gains for resolving issues should be as quantitative as possible; however, at this stage of the analysis, estimates will be crude. While developing a reasonable understanding of the costs involved may not be too difficult, savings estimates are much more problematic since no solution has been developed. Some information is normally available, however, and it should be used to assess the problems and potential gains.

In the Standard Missile example, one of the VE projects involved the transceiver assembly. One potential solution was to replace the assembly with a less costly one. Savings estimates were difficult to obtain because the characteristics of the new assembly were unknown. Another potential solution involved developing a greater level of aggregation. Here, savings would be generated by eliminating tests.

3. Prioritize Issues

While prioritization should weigh the potential gains, it should also consider the likelihood of determining an effective solution and the feasibility of implementing that solution. In the case of the transceiver assembly for the Standard Missile, the second potential solution (developing a greater level of aggregation) was much more straightforward and had a higher likelihood of success than the first potential solution (replacing the assembly with a less costly alternative).

Understanding the importance of the problem to the project sponsor is also a key factor. If the sponsor is determined to solve the problem, the likelihood of success is enhanced. Once management commitment is understood, a useful question to ask is why the problem had not already been solved.

The answer to this question may identify roadblocks to be overcome. Knowing what stands in the way of a solution is another important consideration for prioritization. Finally, other benefits, such as performance improvement, should be considered.

4. Draft a Scope and Objective for the Value Study

The study team's efficiency is significantly enhanced when limits are established in advance. More than one of the constituent problem elements can be included in the scope. The study sponsor must approve the scope. Ultimately, the scope and the objective will be finalized in the Information Phase. This preliminary work will expedite finalization.

5. Establish Evaluation Factors

Targets for improvement should be challenging, and evaluation factors must be measurable. These factors determine the relative importance of the ideas and the potential solutions generated by the team. The study sponsor must approve the improvement targets and the evaluation factors.[28]

6. Determine Team Composition

Essential team member characteristics include technical or functional expertise, problem-solving and decision-making abilities, and interpersonal skills. Participants should be team players who are willing to share responsibilities and accountability while working together toward a common objective. The team should also be multidisciplinary and include all factions affected by the study to ensure that relevant stakeholders and experts are included. J. Jerry Kaufman suggests that because gathering all the information needed to make a "no-risk decision" is impossible, a multidisciplinary team should provide enough different perspectives to at least substantially reduce the risk of ignoring a pertinent viewpoint.[29]

The ideal team size is five to seven people. A team with more than ten participants is difficult to control.[30] After the team members have been selected, the team leader should prepare a management memorandum to be sent to all team members. This memorandum should:

- Emphasize the importance of their role,
- Approve the necessary time commitment,
- Authorize sharing any objective and subjective data that bear on the problem, and
- Identify the team leader.

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[28] In manufacturing-oriented workshops, criteria are not usually selected until competing alternatives have been developed.

[29] J. Jerry Kaufman, *Value Engineering for the Practitioner* (Raleigh, NC: North Carolina State University, 1990), 2–4.

[30] If more participants are needed, the use of on-call experts should be considered.

7. Collect Data

The team leader organizes the data-collection activities in advance of the workshop. As more information is brought to bear on the problem, the probability of substantial benefit increases. To increase the study team's productivity, collecting as much data as possible in advance is crucial. The data-collection effort benefits from having the entire team involved. In fact, some team members may have key information readily available.

The data should be as tangible and quantitative as possible and should include anything potentially useful for understanding the problem, developing solutions, and evaluating the pros and cons of the solutions. The paramount considerations are getting enough facts and getting them from reliable sources.

In addition to possessing specific knowledge of the item or process under study, the team should have all available information concerning the technologies involved and should be aware of the latest technical developments pertinent to the subject being reviewed.

Developing and ranking alternative solutions depend on having reliable cost data. Data on customer and user attitudes also play a key role. Part of the VE study seeks to identify which aspect of the task holds the greatest potential for payoff. This potential for payoff is a function of the importance to the user and customer. The seriousness of user-perceived faults is also a factor in prioritization.

8. Prepare Logistically for the Value Study

The VE study facilitator, who may also be the team leader, prepares the team to participate in the study. He/she is normally certified by SAVE, the VE professional society. The two levels of certification are Certified Value Specialist and Associate Value Specialist.

Initially, brief meetings with potential team members can be held to determine who should participate. The team leader/facilitator should:

- Ensure participants know what data they should bring,
- Set up study facilities and prepare materials (easels, markers, and so forth),
- Set up a kickoff briefing and results briefing with management, and
- Obtain an example of a study item for the team to use.

Pre-study reading materials should be identified and distributed to the participants. Materials that can be assigned as advanced reading include the agenda, operational requirements documents, design documents (drawings and specifications), performance requirements, production quantities, inventory data, failure/quality information, and other documents necessary to ensure a consistent understanding of the issues.

A pre-workshop orientation meeting might be useful to:

- Review workshop procedures;
- Acquaint the team with the problem and read-ahead material;
- Eliminate incorrect preconceived notions about VE, the job plan, the workshop, the problem, the people, and so forth;
- Jump-start the team-building process;
- Clarify acceptable and unacceptable behaviors (i.e., "rules of the road") for team-member participation; and
- Identify additional information needs.

The date should be set reasonably far enough in advance (four to six weeks) to allow personnel to arrange their schedules around the study. When a workshop setting is used, the value study typically takes three to five days.[31]

B. Information Phase

The Information Phase finalizes the scope of the issues to be addressed, the targets for improvement, and the evaluation factors; collects and analyzes the data; and builds cohesion among team members. In many respects, the Information Phase completes the activities begun in the Orientation Phase. This work is normally conducted in a workshop setting and is often the first opportunity for all team members to come together (if no pre-workshop orientation meeting was scheduled). Consequently, the Information Phase should be used to motivate the team to work toward a common goal. Finalizing the scope of the issues to be addressed, the targets for improvement, the evaluation factors, and the data collection and analysis efforts are ideal endeavors for building team cohesion. The following subsections describe the activities during the Information Phase.

1. Establish Workshop Rules of the Road

This activity begins the team-building process; therefore, the facilitator should ensure that all team members know each other and their relevant backgrounds, authority, and expertise. Some authors suggest that team-building exercises should be conducted at the beginning of the workshop.[32] The following guidelines should be established to set the stage for an effective working relationship among the team members:

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[31] Three days may be sufficient for small studies, but five days are more common. To avoid keeping team members away from their jobs for five consecutive days, a separate two-day workshop can be held for the Development and Presentation Phases.

[32] Robert B. Stewart, *Fundamentals of Value Methodology* (Bloomington, IN: Xlibris Corporation, 2005), 113–118.

- Share workload equally whenever possible.
- Be willing to admit not knowing something, but strive to get the answer. Do not be afraid to make mistakes.
- Stay focused and follow the basic problem-solving steps. Do not waste time discussing whether to use each step; complete the steps and conduct an evaluation after completing the entire workshop. Be sure to understand the approach and its purpose, including the reason for each step and the technique being applied. Keep the discussions relevant.
- Work together as a team. Instead of forcing solutions—sell them! A problem can have multiple solutions.
- Be a good listener; do not interrupt or criticize people for what they say.
- Keep an open mind and do not be a roadblock.
- Be enthusiastic about the project and what it is doing.
- Do not attempt to take over as a team leader; be as helpful as possible. The leader already has a difficult job in guiding, controlling, and coordinating the overall effort.
- Accept conflicts as necessary and desirable. Do not suppress or ignore them. Work through them openly as a team.
- Respect individual differences. Do not push each other to conform to central ideas or ways of thinking.
- Work hard. Keep the team climate free, open, and supportive.
- Fully use individual and team abilities, knowledge, and experience.
- Accept and give advice, counsel, and support to each other while recognizing individual accountability and specialization.

2. Finalize the Problem and the Associated Facts

Before starting the analysis, the team should finalize the problem statement to ensure a mutual understanding. This process involves discussing the problem so that all team members achieve a consistent understanding of the issues. The focus should be on the specifics, not generalities. This approach also serves as a useful team-building exercise.

The VE team should begin collecting information before the start of the workshop. If possible, this information should include physical objects (e.g., parts) that demonstrate the problem. When supported facts cannot be obtained, the opinions of knowledgeable people can be used. These people can be invited to participate in the workshop, or their

opinions can be documented. The Information Phase is typically used to familiarize the team members with the data and the data sources in the context of defining the problem. The keys are:

- Getting up-to-date facts from the best sources,
- Separating facts from opinion, and
- Questioning assumptions.

Having all of the pertinent information creates an ideal situation, but missing information should not preclude the performance of the VE effort.

Quality Function Deployment (QFD) is a structured approach to translating customer needs or requirements into specific plans to produce products or develop processes to meet those needs.[33] Henry A. Ball suggests that QFD techniques can be beneficial in the Information Phase because a better understanding of customer requirements leads to a better understanding of product function.[34]

3. Refine the Scope

The problem that has been identified often requires more time than the workshop schedule permits. In these cases, the problem should be re-scoped to ensure that the most important elements are examined during the workshop. Plans for continuing the effort on the balance of the problem can be made at the end of the workshop.

Once the scope is determined and the final set of facts are collected from the best possible data sources, targets for improvement and evaluation factors should be reexamined and finalized. The study sponsor should approve any changes.

C. Function Analysis Phase[35]

The Function Analysis Phase identifies the most beneficial areas for study. The analytical efforts in this phase form the foundation of the job plan. The disciplined use of

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33 Adapted from Kenneth Crow, *Customer-Focused Development with QFD* (Palos Verdes, CA: DRM Associates, 2002). Available: http://www.npd-solutions.com/qfd.html. Additional articles can be found in Robert A. Hunt, and Fernando B. Xavier, "The Leading Edge in Strategic QFD," *International Journal of Quality & Reliability Management* 20, no. 1 (2003): 56–73.

34 Henry A Ball, "Value Methodology—The Link for Modern Management Improvement Tools," in *SAVE International 43rd Annual Conference Proceedings* (Scottsdale, AZ, June 8–11, 2003).

35 Some material in this section was adapted from information in Army Pamphlet 11-3, "Value Engineering" (undated), and DoD Handbook 4245.8-H, "Value Engineering," March 1986.

function analysis distinguishes the value methodology from other improvement methods. The following subsections describe the activities during the Function Analysis Phase.[36]

1. Determine the Functions

For the product or process under study, this activity encompasses determining forty to sixty functions that are performed by the product, the process, or any of the parts or labor operations. Functions are defined for every element of the product or process that consumes resources. The functions are typically recorded on adhesive-backed cards for later manipulation.

A function is defined as "the original intent or purpose that a product, service, or process is expected to perform."[37] Unstructured attempts to define the function(s) of a product or process will usually result in several concepts described in many words. Such an approach is not amenable to quantification. In VE, a function must be defined by two words: an active verb and a measurable noun:

- The verb should answer the question, "What does it do?" For example, it may generate, shoot, detect, emit, protect, or launch. This approach is a radical departure from traditional cost-reduction efforts because it focuses attention on the required action rather than the design. The traditional approaches ask the question, "What is it?" and then concentrate on making the same item less expensive by answering the question, "How do we reduce the cost of this design?"
- The noun answers the question, "What does it do this to?" The noun tells what is acted upon (e.g., electricity, bullets, movement, radiation, facilities, or missiles). It must be measurable or at least understood in measurable terms since a specific value must be assigned to it during the later evaluation process that relates cost to function.

A measurable noun, together with an active verb, provides a description of a work function (e.g., generate electricity, shoot bullets, detect movement, and so forth).

A work function establishes quantitative statements. Functional definitions containing a verb and a non-measurable noun are classified as sell functions. They establish qualitative statements (e.g., improve appearance, decrease effect, increase convenience, and so forth). Providing the correct level of function definition is important. For example,

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[36] These activities are adapted from SAVE International, *Function: Definition and Analysis* (October 1998), http://www.value-eng.org/pdf_docs/monographs/funcmono.pdf. They are consistent with those listed in SAVE International, *Value Standard and Body of Knowledge* (SAVE International Standard, June 2007), http://www.scribd.com/doc/15563084/Value-Standard-and-Body-of-Knowledge.

[37] SAVE International, *Value Standard and Body of Knowledge* (SAVE International Standard, June 2007), 28, http://www.scribd.com/doc/15563084/Value-Standard-and-Body-of-Knowledge.

the function of a water service line to a building could be stated as "provide service." "Service," not being readily measurable, is not amenable to determining alternatives. On the other hand, if the function of the line was stated as "conduct fluid," the noun in the definition is measurable, and the alternatives dependent upon the amount of fluid being transported can be readily determined.

Defining a function in two words, a verb and a noun, is known as two-word abridgment. The advantages are that it:

- Forces brevity. If a function cannot be defined in two words, insufficient information is known about the problem or the segment of the problem being defined is too large.
- Avoids combining functions and defining more than one simple function. By using only two words, the problem is broken down into its simplest element.
- Aids in achieving the broadest level of dissociation from specifics. When only two words are used, the possibility of faulty communication or misunderstanding is minimized.
- Focuses on function rather than on the item.
- Encourages creativity.
- Frees the mind from specific configurations.
- Enables the determination of unnecessary costs.
- Facilitates comparison.

2. Classify the Functions

The second major activity in the Function Analysis Phase is to group the functions into two categories: basic and secondary.

The basic function is the intent and purpose of a product or process and answers the question, "What must it do?" Basic functions have or use value. A basic function defines the specific purpose(s) for which a product, facility, or service exists and conveys a sense of "need."[38]

A product or service can possess more than one basic function, determined by considering the user's needs. A non-load-bearing exterior wall might be initially defined by the function description "enclose space." However, further function analysis determines that, for this particular wall, two basic functions are more definitive than the initial one:

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[38] Ibid.

"secure area" and "shield interior." Both functions answer the question, "What does it do?"

Secondary functions answer the question "What else does it do?" Secondary functions are support functions and usually result from the particular design configuration. Generally, secondary functions contribute greatly to cost and may or may not be essential to the performance of the primary function. They support the basic function and result from the specific design approach used to achieve the basic function. [39]

As methods or design approaches to achieve the basic function are changed, secondary functions can also change. Three kinds of secondary functions are as follows:

1. **Required secondary functions.** These functions are necessary in a product or project to perform the basic function. For example, battery-operated flashlights and kerosene lanterns perform the basic function of producing light. A required secondary function, however, in the flashlight is to "conduct current" while the equivalent secondary function in the lantern is to "conduct fluid."
2. **Aesthetic secondary functions.** These functions add beauty or decoration to the product or project and are generally associated with "sell functions." For example, the colors of paint available for a car could be an aesthetic secondary function.
3. **Unwanted secondary functions.** These functions, by definition, are not wanted while the product is performing the basic or secondary function(s). For example, while the kerosene lantern performs the basic function of producing light, an unwanted secondary function is that it "produces odor."[40]

Secondary functions that lend esteem value (convenience, user satisfaction, and appearance) are permissible only if they are necessary to permit the design or item to work or sell. These functions sometimes play an important part in the marketing or acceptance of a design or product. VE separates costs required for basic function performance from those incurred for secondary functions to eliminate as many non-value-added secondary functions as possible, improve the value of the remaining functions, and still provide the appeal necessary to permit the design or product to sell.

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[39] Ibid.

[40] James D. Bolton, Don J. Gerhart, and Michael P. Holt, *Value Methodology: A Pocket Guide to Reduce Cost and Improve Value Through Function Analysis* (Lawrence, MA: GOAL/QPC, 2008), 46.

3. Develop Function Relationships

Two principal techniques have been developed to create a better understanding of function relationships: a function hierarchy logic model and the Function Analysis System Technique (FAST).[41] This document concentrates on the classical FAST approach and the use of the FAST diagram.[42] FAST was developed by Charles W. Bytheway of the Sperry Rand Corporation and introduced in a paper presented at the 1965 National Conference of the Society of American Value Engineers in Boston. Since then, FAST has been widely used by government agencies, private firms, and VE consultants. FAST is particularly applicable to a total project, program, or process requiring interrelated steps or a series of actions. Figure 6 illustrates a classical FAST diagram.

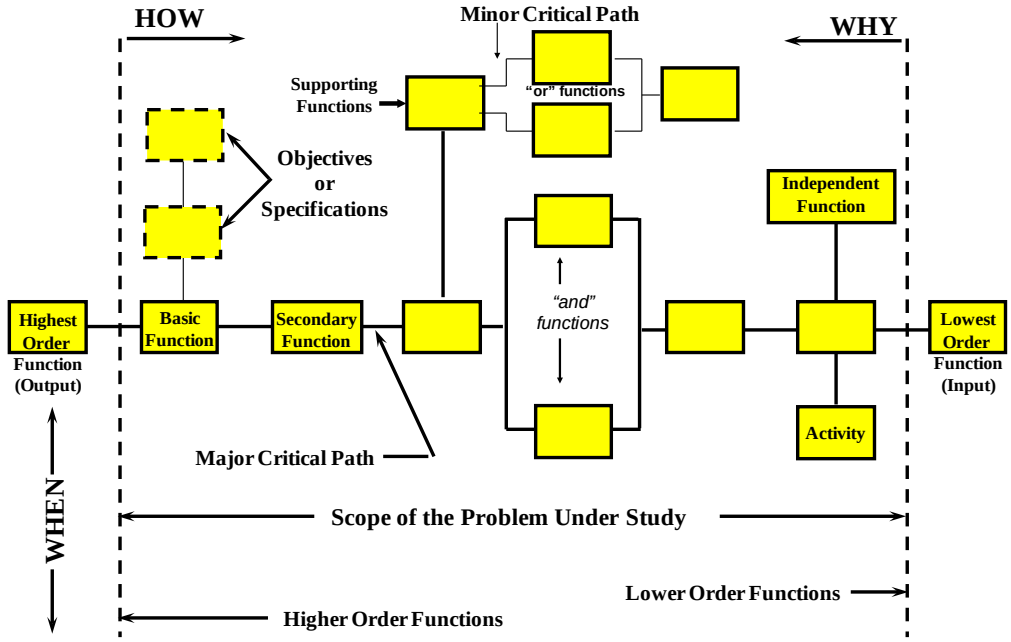

Figure 6. Illustrative Classical Function Analysis System Technique (FAST) Diagram

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41 These two approaches are described on an overview basis and illustrated using the same project in Save International, *Function Relationships – An Overview* (SAVE International Monograph, 1999).

42 In addition to classical FAST, there are technical FAST and customer FAST. Technical FAST and customer FAST follow slightly different rules and formats. Additional information about the Function Hierarchy Logic model can be found in SAVE International, *Function Logic Models* (n.d.), http://www.value-eng.org/pdf_docs/monographs/funclogic.pdf. The equivalent publication on FAST is Save International, Functional Analysis Systems Techniques – The Basics (SAVE International Monograph (n.d.)), http://www.value-eng.org/pdf_docs/monographs/FAbasics.pdf. The Army has published some FAST training material: *Function Analysis System Technique (FAST) Student Guide*, prepared by Nomura Enterprise, Inc., and J. J. Kaufman Associates, Inc., for the U.S. Army Industrial Engineering Activity, Rock Island, Illinois. The approach outlined in this section most closely follows J. Jerry Kaufman, *Value Engineering for the Practitioner* (Raleigh, NC: North Carolina State University, 1990).

The basic classical FAST steps are as follows:

- **Step 1:** Determine the highest order function. "The objective of the value study is called the Highest Order Function(s) and is located to the left of the basic function(s) and outside the left scope line."[43] Determining the highest order function is not always an easy process. For instance, the most offered highest order function for a cigarette lighter is "lights cigarettes." This characterization, however, immediately raises the obvious question, "What about pipes and cigars?" An alternative might then be "generates flame." However, the electrical resistance lighter in a car only "emits energy." The thought process must focus in either one direction or another to develop a multiplicity of two-word abridgements from which one or more levels can be chosen as the level of the basic functions to be studied.
- **Step 2:** Identify the basic functions. Select the basic functions that directly answer the question, "How does the product or process perform the highest order function?" If all direct answers are not among the existing basic functions, create a new one. All of these basic functions should be included in the first column to the right of the higher order function.
- **Step 3:** Expand the FAST diagram. Keep asking how the function is performed from the viewpoint of a user. Most answers will be found among the existing functions. Add second, third level, and lesser functions as needed to the right of the basic functions but do not expand a function unless the "how" question is answered by two or more functions. Repeating the "how" question in this way is sometimes called the "ladder of abstraction" method. It is a thought-forcing process. Because using more than one definition can generate more creative ideas, this approach leads to greater fluency (more ideas), greater flexibility (variety of ideas), and improved function understanding of the problem. It generates critical paths for achieving the basic functions.
- **Step 4:** Identify the supporting functions. Supporting functions do not depend on another function. They are placed above a critical path and usually are needed to achieve the performance levels specified for the critical path function they support. The supporting functions above the critical path and the activities below the critical path are the result of answering the "when" question for a function on the critical path. A supporting function can have its own minor critical path.

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[43] Robert B. Stewart, *Fundamentals of Value Methodology* (Bloomington, IN: Xlibris Corporation, 2005), 182.

- **Step 5:** Verify the FAST diagram. The FAST diagram is verified by driving one's thinking up the ladder of abstraction. Asking "why" raises the level, making the function description more general. In practice, the desired level is one that makes possible the largest number of feasible alternatives. Since the higher levels are more inclusive and afford more opportunities, the desired level is the highest level that includes applicable, achievable alternatives. A practical limit to the "why" direction is the highest level at which the practitioner is able to make changes. If the level selected is too low, alternatives can be restricted to those that resemble the existing design. If the level selected is too high, achievable alternatives can be obscured, and alternatives that are beyond the scope of effort might be suggested.

FAST is generally used to understand a problem, issue, or opportunity. However, developing a FAST diagram can be a difficult and time consuming effort, but the decision to use a FAST diagram should be based on an understanding of the problem. The following broad considerations apply to such a decision:

- The more complicated the situation, the more useful a FAST diagram will be.
- If the situation is not well understood, a FAST diagram should be used.
- If there are more than three stakeholders that need to come to a common understanding of the situation, a FAST diagram should be used.
- If during the initial function analysis, it is discovered that there are multiple secondary functions (particularly if they are co-dependent), a FAST diagram should be used.
- If the project is being carried out by a single individual, a FAST should not be used unless the individual is already skilled at the technique.
- A FAST diagram should not be used if no one in the group has performed a Function Analysis before.
- If the scope is narrow and constrained, a FAST diagram may not be necessary.

4. Estimate the Cost of Performing Each Function

All VE studies include some type of economic analysis that identifies areas of VE opportunity and provides a monetary base from which the economic impact can be determined. The prerequisite for any economic analysis is reliable and appropriate cost data. Consequently, the VE study should use the services of one or more individuals who are skilled in estimating, developing, and analyzing cost data. The cost of the original or present method of performing the function (i.e., the cost for each block of the FAST diagram) is determined as carefully and precisely as possible given the time constraints for preparing the estimate.

The accuracy of a cost estimate for a product depends on the:

- Maturity of the item,
- Availability of detailed specifications and drawings, and
- Availability of historical cost data.

Similarly, the accuracy of a cost estimate for a service depends on the:

- People involved,
- Time spent performing the service,
- Waiting time, and
- Direct, indirect, and overhead labor and material costs.

In some cases, a VE study will involve both products and processes.

5. Determine the Best Opportunities for Improvement

The objective of this activity is to select functions for continued analyses. It is often accomplished by comparing function worth to function cost, where value is defined by the ratio of worth to cost (or cost to worth).[44] *Function worth* is defined as the lowest cost to perform the function without regard to consequences.

Thus, the use of function worth focuses the VE effort on those functions that will be most worthwhile and provides a reference point to compare alternatives. It can even be used as a psychological incentive to discourage prematurely stopping the VE effort before all of the alternatives are considered.

Determining the worth of every function is usually not necessary. Cost data aid in determining the priority of effort. Because significant savings potential in low-cost areas may not be a worthwhile pursuit and high-cost areas may be indicative of poor value, the latter are prime candidates for initial function worth determinations. Costs are usually distributed in accordance with Pareto's Law of Maldistribution: a few areas, "the significant few," (generally 20 percent or less) represent most (80 percent or more) of the cost. Conversely, 80 percent of the items, "the insignificant many," represent only 20 percent of total costs. Figure 7 illustrates this relationship.

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[44] In practice, determining function worth is often difficult. As an alternative, total function cost can be distributed in a matrix where rows are the functions and columns are components of a product or departments in a service or process scenario. Best opportunities for improvement are sought among the highest cost functions. The relative worth of components can also be inferred from a customer's relative value of design functions. An interesting example of using QFD to do this can be found in K. Ishii and S. Kmenta, *Life-cycle Cost Drivers and Functional Worth*, Project Report for ME317: Design for Manufacturing, Department of Mechanical Engineering (Palo Alto, CA: Stanford University, n.d.).

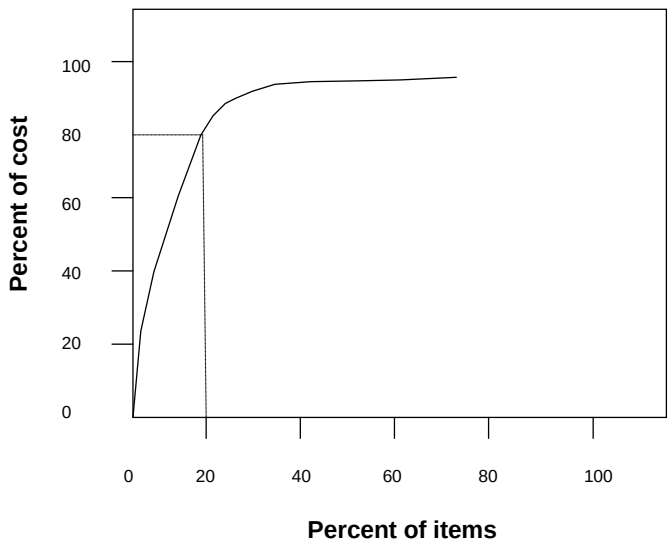

Figure 7. Pareto's Law of Maldistribution

A technique for developing the worth of functions, conceived in the early days of VE and still effective today, Pareto's Law of Maldistribution compares the selected function to the simplest method or product that can be imagined to achieve the same result. One increasingly popular technique for assigning worth to functions ascertains the primary material cost associated with the function.[45]

The value calculation can be done in many ways. For example, some workshop facilitators use a ratio of "percent relative importance" to "percent of cost." In this approach, all functions are evaluated pairwise, with different numbers assigned to reflect the relative importance of the two functions being compared (e.g., three may mean a large difference in importance, 1 may mean a small difference in importance). A relative importance is calculated for each function individually as the sum of the relative importance scores that function received when it was ranked higher than another function in the pairwise comparisons. The "percent relative importance" is calculated by converting the individual function's relative importance scores to a percentage of the total. The "percent of cost" is the cost of a function relative to the total cost of all functions.[46] There are other approaches. For example, Thomas Snodgrass suggests an alternative approach

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45 SAVE International, *Function: Definition and Analysis* (October 1998), http://www.value-eng.org/pdf_docs/monographs/funcmono.pdf.

46 A more complete description can be found in Arthur E. Mudge, *Value Engineering – A Systematic Approach* (Pittsburgh, PA: J. Pohl Associates, 1989), 68–74.

based on high, medium, and low scores for function acceptance, function cost, and function importance. [47]

Whatever approach is used, the best opportunities for improvement are determined by improving functions that have excessively low ratios of worth to cost (or high ratios of cost to worth). This ratio is referred to as the value index.

6. Refine Study Scope

The final activity in the Function Analysis Phase refines the study scope to reflect any changes that have taken place.

D. Creative Phase

The Creative Phase develops ideas for alternative ways to perform each function selected for further study. The two approaches to solving a problem are analytical and creative. In the analytical approach, the problem is stated, and a direct, step-by-step approach to the solution is taken. An analytical problem frequently has only one solution that will work. The analytical approach should *not* be used in the Creative Phase. The creative approach is an idea-producing process specifically intended to generate a number of solutions that solve the problem at hand. All solutions could work, but one is better than the others. It is the optimum solution among those available. Once a list of potential solutions is generated, determining the best value solution is an analytical process conducted in the latter phases of the job plan.

Creative problem-solving techniques are an indispensable ingredient of effective VE. By using the expertise and experience of the study team members, new ideas will be developed. The synergistic effect of combining the expertise and experience of all team members will lead to a far greater number of possibilities. The following subsections describe the activities during the Creative Phase (also called the Speculation Phase).

1. Discourage Creativity Inhibitors

For these activities to work well, the team must avoid mental attitudes that hinder creativity. The facilitator should point out creativity inhibitors to the team. Awareness of these inhibitors encourages people to overcome them. Parker identifies the following as common habitual, perceptual, cultural, and emotional blocks to creativity:[48]

- Habitual blocks

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47 Thomas J. Snodgrass, "Function Analysis and Quality Management," in *SAVE International 33rd Annual Conference Proceedings* (1993).

48 Donald E. Parker, *Value Engineering Theory*, rev. ed. (Washington, D.C.: The Lawrence D. Miles Value Foundation, 1998), 93.

  - Continuing to use “tried and true” procedures even though new and better ones are available
  - Rejecting alternative solutions that are incompatible with habitual solutions
  - Lacking a positive outlook, lacking effort, conformity to custom, and reliance on authority
- Perceptual blocks
  - Failure to use all the senses for observation
  - Failure to investigate the obvious
  - Inability to define terms
  - Difficulty in visualizing remote relationships
  - Failure to distinguish between cause and effect
  - Inability to define the problem clearly in terms that will lead to the solution of the real problem
- Cultural blocks[49]
  - Desire to conform to proper patterns, customs, or methods
  - Overemphasis on competition or cooperation
  - The drive to be practical above all else, thus making decisions too quickly
  - Belief that all indulgence in fantasy is a waste of time
  - Faith only in reason and logic
- Emotional blocks
  - Fear of making a mistake or of appearing foolish
  - Fear of supervisors and distrust of colleagues
  - Too much emphasis on succeeding quickly
  - Difficulty in rejecting a workable solution and searching for a better one
  - Difficulty in changing set ideas (no flexibility) and depending entirely upon judicial (biased) opinion
  - Inability to relax and let incubation take place

The following list adapted from Michel Thiry’s “good idea killers” could also be used to make the team aware of attitudes to avoid:[50]

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[49] Political blocks can also be included here.

- It is not realistic.
- It is technically impossible.
- It does not apply.
- It will never work.
- It does not correspond to standards.
- It is not part of our mandate.
- It would be too difficult to manage.
- It would change things too much.
- It will cost too much.
- Management will never agree.
- We do not have time.
- We have always done it that way.
- We already tried it.
- We have never thought of it that way.
- We are already too far into the process.

The Creative Phase does not necessarily identify final solutions or ideas ready for immediate implementation. It often simply provides leads that point to final solutions.

Beginning the Creative Phase with a creativity-stimulating exercise can also be useful. J. Jerry Kaufman and James D. McCuish[51] report a threefold increase in ideas with the use of a stimulus. They suggest using the Impossible Invention creativity exercise developed in the Massachusetts Institute of Technology (MIT) creativity lab in the 1960s. This 30-minute exercise consists of dividing the participants into three- or four-person teams. Each team then progresses through preliminary steps to select the three worst ways to perform the function without knowing why or the parameters that define worst. The objective of the exercise is for team members—as a team and as individuals—to experience how far beyond the teams' paradigm they can venture in an environment in which their self-esteem is protected.

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50 Michel Thiry, *Value Management Practice* (Newtown Square, PA: Project Management Institute, 1997), 57.

51 J. Jerry Kaufman and James D. McCuish, "Getting Better Solutions with Brainstorming," in *SAVE International 42nd Annual Conference Proceedings* (Denver, CO, May 5–8, 2002).

2. Establish Ground Rules

The ground rules for creative idea generation, as adapted from Parker,[52] are summarized as follows:

- Do not attempt to generate new ideas and judge them at the same time. Reserve all judgment and evaluation until the Evaluation Phase.
- Focus on quantity, not quality. Generate a large quantity of possible solutions. As a goal, multiply the number of ideas produced in the first rush of thinking by five or even ten.
- Seek a wide variety of solutions that represent a broad spectrum of attacks on the problem. The greater the number of ideas conceived, the greater likelihood of an alternative that leads to better value.
- Freewheeling is welcome. Deliberately seek unusual ideas.
- Watch for opportunities to combine or expand ideas as they are generated. Include them as new ideas. Do not replace anything.
- Do not discard any ideas, even if they appear to be impractical.
- Do not criticize or ridicule any ideas. (Criticism could be discouraged, for example, by maintaining a criticizer list or imposing a mock penalty on criticizers.)

3. Generate Alternative Ideas

In this phase of the study, generating a free flow of thoughts and ideas for alternative ways to perform the functions—not how to design a product or service—is important. While creativity tools are available for problem-solving situations, no specific combination of techniques is prescribed for all VE projects, and the degree to which they should be used is not predetermined. The selection of specific techniques and the depth to which they are used are primarily matters of judgment and vary according to the complexity of the subject under review.

The following list of idea-generation techniques describes some commonly used approaches in the VE context:[53]

- **Brainstorming**. Brainstorming is a free-association technique that groups use to solve specific problems by recording spontaneous ideas generated by the group.

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[52] Donald E. Parker, *Value Engineering Theory*, rev. ed. (Washington, D.C.: The Lawrence D. Miles Value Foundation, 1998), 96.

[53] Some of the following material was adapted from information in Army Pamphlet 11-3, *Value Engineering* (n.d.), and DoD Handbook 4245.8-H, *Value Engineering* (March 1986).

It is primarily based on the premise that one idea suggests others, which suggest even more. An individual can brainstorm, but experience has shown that a group can generate more ideas collectively than the same number of persons thinking individually. Roger B. Sperling has suggested combining group and individual brainstorming.[54] He found that after the group brainstorming was complete, individual brainstorming can generate additional ideas of comparable quality.

- **Gordon technique.** The Gordon technique is closely related to brainstorming. The principal difference is that no one except the group leader knows the exact nature of the problem under consideration. This difference helps avoid the premature ending of the session or egocentric involvement. A participant may cease to produce additional ideas or devote energy only to defending an idea if he/she is convinced that one of the ideas already proposed is the best solution to the problem. Selecting a topic for such a session is more difficult than selecting a topic for a brainstorming session. The subject must be closely related to the problem at hand, but its exact nature must not be revealed until the discussion is concluded.
- **Checklist.** The checklist technique generates ideas by comparing a logical list of categories with the problem or subject under consideration. Checklists range from the specialized to the extremely general.
- **Morphological analysis.** Morphological analysis is a structured, comprehensive system for methodically relating problem elements to develop new solutions. In this approach, the problem is defined in terms of its dimensions or parameters, and a model is developed to visualize every possible solution. Problems with too many parameters rapidly become intractable.
- **Attribute listing.** The attribute listing approach lists all of the various characteristics of a subject first and then measures the impact of changes. By so doing, new combinations of characteristics (attributes) that will better fulfill some existing need can be determined.
- **Input-output technique.** The input-output technique establishes output, establishes input as the starting point, and varies combinations of input/output until an optimum mix is achieved.
- **Theory of Inventive Problem Solving (TRIZ).** TRIZ (stands for the Russian phrase Teoriya Resheniya Izobretatelskikh Zadatch) is a management tool that will be used more fequently with greater awareness of its capabilities. The methods and tools are embodied in five steps: problem documentation and

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[54] Roger B. Sperling, "Enhancing Creativity with Pencil and Paper," in *SAVE International 39th Annual Conference Proceedings* (San Antonio, TX, June 27–30, 1999), 284–289.

preliminary analysis, problem formulation, prioritization of directions for innovation, development of concepts, and evaluation of results. C. Bernard Dull points out that both VE and TRIZ have strengths and weaknesses.[55] Combining these two problem-solving methodologies can create synergies that lead to more robust and comprehensive results, especially for more technically complex projects where the added benefit is worth the effort. He suggests that integrating TRIZ into the VE job plan is easier than integrating VE into the TRIZ job plan. Dana W. Clarke goes into greater detail in the Creative Phase by suggesting how TRIZ can be used to augment traditional brainstorming.[56] Ball supports Clarke's conclusion stating: "This is a much more intensive method of identifying potential solutions than generally used in a VM [Value Management] study."[57]

When using any one of these techniques, the team reviews the elements of the problem several times. If possible, new viewpoints should be obtained by discussing the problem with others. Different approaches should be used if one technique proves to be ineffective.[58] However, before rejecting any possible solutions, one effective strategy allows the team to take a break to allow time for subconscious thought on the problem while consciously performing other tasks.

E. Evaluation Phase

The Evaluation Phase selects and refines the best ideas to develop into specific value improvement recommendations. Ultimately, the team should present the decision-maker a small number (e.g., fewer than six) of choices. In the Creative Phase, a conscious effort was made to prohibit judgmental thinking because it inhibits the creative process. In the Evaluation Phase, all the alternatives must be critically assessed to identify the best opportunities for value improvement. This phase is not the last chance to defer ideas. A detailed cost-benefit analysis conducted in the Development Phase leads to the final set of choices presented to the decision-maker. The following subsections describe the activities during the Evaluation Phase.

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55 C. Bernard Dull, "Comparing and Combining Value Engineering and TRIZ Techniques," in *SAVE International 39th Annual Conference Proceedings* (San Antonio, TX, June 27–30, 1999), 71–76.

56 Dana W. Clarke, Sr., "Integrating TRIZ with Value Engineering: Discovering Alternative to Traditional Brainstorming and the Selection and Use of Ideas," in *SAVE International 39th Annual Conference Proceedings* (San Antonio, TX, June 27–30, 1999), 42–51.

57 Henry A Ball, "Value Methodology – The Link for Modern Management Improvement Tools," in *SAVE International 43rd Annual Conference Proceedings* (Scottsdale, AZ, June 8–11, 2003).

58 Some work has been done on a systematic approach for moving between creative methodologies. See Donald Hannan, "A Hybrid Approach to Creativity," in *SAVE International 41st Annual Conference Proceedings* (Fort Lauderdale, FL, May 6–9, 2001).

1. Eliminate Low-Potential Ideas

Ideas that are not feasible, too hard, not promising, or do not perform the basic function should be eliminated. A useful approach to this activity is to classify the ideas into three categories:

- **Yes.** These ideas appear to be feasible and have a relatively high probability of success.
- **Maybe.** These ideas have potential but appear to need additional refinement or work before they can become proposals.
- **Not Now.** These ideas have little or no potential at this time.

At this point, eliminate only the "not now" ideas.

2. Group Similar Ideas

The remaining ideas are grouped into several (three or more) subject-related categories and examined to determine if they should be modified or combined with others. Sometimes, the strong parts of two different ideas can be developed into a winning idea. In other cases, several ideas can be so similar that they can be combined into a single all-encompassing idea. Some workshops employ a "forced relationships" technique that deliberately attempts to combine ideas from the different subject-related categories to discover new, innovative alternatives.

3. Establish Idea Champions

The remaining activities in this phase are designed to prioritize the ideas for further development. An idea champion is a study team member who will serve as an idea's proponent throughout the prioritization process. If an idea has no champion, it should be eliminated at this point.

4. List the Advantages and Disadvantages of Each Idea

The advantages and disadvantages of each idea are identified along with the ease of change, cost, savings potential, time to implement, degree to which all requirements are met, and likelihood of success. All of the effects, repercussions, and consequences that might occur in trying to accomplish a solution should be anticipated.

Useful suggestions include how to overcome the disadvantages. No matter how many advantages an idea has, disadvantages that cannot be overcome may lead to its rejection.

5. Rank the Ideas

A set of evaluation criteria should be developed to judge the ideas, using the factors considered when listing advantages and disadvantages (e.g., cost, technical feasibility, likelihood of approval, time to implement, and potential benefit). The ideas should be ranked according to the criteria that have been developed. No idea should be discarded, and all ideas should be evaluated as objectively as possible. Ratings and their weights are based on the judgment of the people performing the evaluation. Techniques such as evaluation by comparison, numerical evaluation, or team consensus can be used. Simplified decision analysis techniques such as QFD can also be applied. Yuh-Huei Chang and Ching-Song Liou suggest using a simplified risk identification and analysis process to evaluate the performance of alternatives and combining these results with criteria weights to determine the best alternatives for further development.[59]

This initial analysis will produce a shorter list of alternatives, each of which has met the evaluation standards set by the team. At this point in the Evaluation Phase, adapting an idea suggested by John D. Pucetas for the Creative Phase might be useful. Pucetas recommends using Force Field Analysis, which evaluates helping and hindering forces in the pursuit of a product, to "measure the sensitivity of the VE team regarding controversial project issues."[60] For the higher-ranked ideas, the VE team should suggest ways to reduce the disadvantages and enhance the advantages. This exercise can lead to the following potential benefits:

- Ideas can be revised to improve their potential for success.
- Insight into implementation issues can be obtained from the suggested ways to reduce the disadvantages.
- Insight into the acceptability of the idea and the likelihood of management approval can be derived from suggested ways to enhance the advantages.

This approach can serve as a basis for distinguishing among the higher-ranked ideas (i.e., re-ranking the ideas) and, as a consequence, simplifying and strengthening the procedure for selecting ideas for further development.

6. Select Ideas for Further Development

Typically, a cutoff point is established for identifying ideas for further development. If a natural break occurs in quantitative evaluation scores, a cutoff point may be obvious.

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[59] Yuh-Huei Chang and Ching-Song Liou, "Implementing the Risk Analysis in Evaluation Phase to Increase the Project Value," in *SAVE International 45th Annual Conference Proceedings* (San Diego, CA, June 26–29, 2005).

[60] John D. Pucetas, "Keys to Successful VE Implementation," in *SAVE International 38th Annual Conference Proceedings* (Washington, D.C., June 14–17, 1998), 340.

If only qualitative evaluation scores are used or if quantitative scores are close, a more refined ranking scheme may be needed to make the selection. However, if several alternatives are not decisively different at this point, they should be developed further.

Alternatives with the greatest value potential will normally be among those selected. If that is not the case, those ideas should be reexamined to determine whether they should be developed further. Retaining at least one idea from each of the subject-related categories used to group ideas at the beginning of the Evaluation Phase is also useful.

F. Development Phase

The Development Phase determines the "best" alternative(s) for presentation to the decision-maker. In this phase, detailed technical analyses are made for the remaining alternatives. These analyses form the basis for eliminating weaker alternatives. The following subsections describe the activities during the Development Phase.

1. Conduct a Life-Cycle Cost Analysis

A life-cycle cost analysis ranks all remaining alternatives according to an estimate of their life-cycle cost-reduction potential relative to the status quo. Cost estimates must be as complete, accurate, and consistent as possible to minimize the possibility of error in assessing the relative economic potential of the alternatives. Specifically, the method used to cost the status quo should also be used to cost the alternatives.

All costs should be identified. For the originating organization, costs may include:

- New tools or fixtures,
- Additional materials,
- New assembly instructions,
- Changes to plant layout and assembly methods,
- Revisions to test and/or inspection procedures,
- Retraining assembly, test, or inspection personnel,
- Reworking parts or assemblies to make them compatible with the new design, and
- Tests for feasibility.

Other costs that are not normally incurred by the originating activity but should be considered include:

- Technical and economic evaluation of proposals by cognizant personnel;
- Prototypes;

- Testing the proposed change, including laboratory, firing range, and missile-range charges;
- Additional equipment that must be provided;
- If applicable, retrofit kits (used to change design of equipment already in field use);
- Installation and testing of retrofit kits;
- Changes to engineering drawings and manuals;
- Training personnel to operate and maintain the new item;
- Obtaining new and deleting obsolete stock numbers;
- Paperwork associated with adding or subtracting items from the supply system;
- Maintaining new parts inventory in the supply system (warehousing);
- Purging the supply system of parts made obsolete by the change; and
- Changing contract work statements and specifications to permit implementation of the proposal.

Determining the precise cost associated with a proposed change is not always possible. For example, the actual cost of revising, printing, and issuing a page of a maintenance manual is difficult to obtain. Nevertheless, this charge is a recognized item of cost because the manual must be changed if the configuration of the item is changed. One common practice uses a schedule of surcharges to cover areas of cost that defy precise determination. Such a schedule is usually based on the average of data obtained from various sources.

Comparing alternatives using a "constant dollar" analysis instead of a "current dollar" approach is easier. It permits labor and material cost estimates to be based on current operational and maintenance data and eliminates the need to figure out how they would inflate in some future year. The net present worth of each of the alternatives should be calculated but only after management agrees on two factors:

- **The discount rate to be used.** This figure is the difference between the inflation rate assumed and the time value of money (interest rate).
- **The length of the life cycle.** This measurement is the number of years of intended use or operation of the object being studied.

The Office of Management and Budget provides annual guidance on appropriate discount rates.[61] Normally, the Department of Defense allows a period of fifteen to twenty years as

[61] OMB Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" The Office of Management and Budget, (Washington, D.C., 1992).

a reasonable life cycle. However, a program or a command may have different guidance for a particular situation.

2. Determine the Most Beneficial Alternatives

In evaluating the alternatives, the VE team should consult personnel who have knowledge about the item's function, operational constraints, dependability, and requirements. Technical problems related to design, implementation, procurement, or operation must also be determined and resolved. Certain key questions should be answered as part of this effort:

- What are the life-cycle savings?
- Do the benefits outweigh the costs?
- What are the major risks?
- How can the risks be mitigated?
- Are any technical issues outstanding?

If more than one alternative offers significant savings potential, the common practice is to recommend all of them. One becomes the primary recommendation, and the others are alternative recommendations, usually presented in decreasing order of saving potential. Other non-quantified benefits should also be considered.

3. Develop Implementation (Action) Plans

The implementation plan for each alternative should include a schedule of the required implementation steps; identify who will execute the plan; specify the resources required, the approval process, the necessary documents, the timing requirements, the coordination required; and so forth. The team must anticipate problems relating to implementation and propose specific solutions to each. Discussions with specialists in relevant areas are particularly helpful in solving such problems.

When needed, testing and evaluation should be planned for and scheduled during the recommended implementation process. Occasionally, concurrent testing of two or more proposals allows a significant reduction in the implementation investment. Also, significant reductions in testing costs can often be achieved by scheduling tests into other test programs scheduled within the desirable time frame—especially when items to be tested are a part of a larger system also being tested. However, care must be exercised during combined testing to prevent masking the feasibility of one concept by the failure of another.

G. Presentation Phase

The purpose of the Presentation Phase is to obtain a commitment to follow a course of action and initiate an alternative. The VE team makes a presentation to the decision-maker (or study sponsor) at the conclusion of the workshop. This presentation is normally the first step (not the last step) in the approval process. Typically, a decision to implement is not made at the time of the briefing.

Additional steps include:

- Answering follow-on questions,
- Collecting additional data,
- Reviewing supporting documentation, and
- Involving other decision-makers.

The sole activity during this phase involves preparing a presentation to encourage commitment. An oral presentation can be the cornerstone to selling a proposal. It should have an impact and continue the process of winning management and other stakeholder support. This presentation gives the VE team a chance to ensure that its written proposal is correctly understood and that proper communication exists between the parties concerned. The presentation's effectiveness will be enhanced if:

- The entire team is present and introduced;
- The presentation lasts no longer than twenty minutes, with time for questions at the end;
- The presentation is illustrated using mockups, models, slides, vu-graphs, or flip charts; and
- The team has prepared sufficient backup material to answer all questions posed during the presentation.

The presentation itself should:

- Describe the workshop objectives and scope;
- Identify the team members and recognize their contributions;
- Describe the "before" and "after" conditions for each alternative;
- Present the costs and benefits, advantages and disadvantages, and impact of each alternative;
- Identify strategies to overcome roadblocks;
- Demonstrate the validity of the data sources; and
- Suggest an action plan and implementation schedule.

The most successful strategies to improve the probability of success and reduce the time required for acceptance and implementation of proposals appear to be the following:

- **Consider the reviewer's needs.** Terminology appropriate to the training and experience of the reviewer should be used. Each proposal is usually directed toward two audiences: (1) the technical authority that requires sufficient technical detail to demonstrate the engineering feasibility of the proposed change and (2) the administrative reviewers for whom the technical details can be summarized but for whom the financial implications (cost and likely benefits) are emphasized. Long-range effects on policies, procurement, and applications are usually more significant to the administrator than to the technical reviewer.
- **Address risk.** Decision-makers are often more interested in the risk involved in making a decision than the benefits or value that might be achieved by the decision. Decision-making risk should not be confused with technical risk. Decision-making risk encompasses the uncertainty and complexity generated from making a change. Therefore, the organizational culture and behavior should be considered when characterizing the recommendation.
- **Relate benefits to organizational objectives.** A proposal that represents advancement toward some approved objective is most likely to receive favorable consideration from management. Therefore, the presentation should exploit all of the advantages that a proposal can offer toward fulfilling organizational objectives and goals. When reviewing a proposal, the manager normally seeks either lower total cost of ownership or increased capability at the same or lower cost. The objective may be not only savings, but also the attainment of some other mission-related goal of the manager.
- **Show collateral benefits of the investment.** Often, VE proposals offer greater benefits than the cost improvement specifically identified. Some of the benefits are collateral in nature and can be difficult to quantify. Nevertheless, collateral benefits should be included in the proposal. The likelihood of the proposal's acceptance is improved when all of its collateral benefits are clearly identified and completely described.

The Presentation Phase should end with a list of actions leading to approval:

- Preparation and submission of a final workshop report with all the necessary supporting documentation
- Briefings to other key stakeholders
- A schedule for a follow-up meeting to approve the proposal

H. Implementation Phase

The purpose of the Implementation Phase is to obtain final approval of the proposal and facilitate its implementation. Throughout this phase, the team should be mindful of factors that contribute to successful change. According to R. A. Fraser:

> The VE/VA techniques provide an excellent method for planned and managed change. However, even when the job plan is applied well, challenges to the change process occur due to individual differences and human interpretation. At each stage of the change process, a number of varying responses may be expected from individuals involved throughout the organization. These responses range from active support to resistance. One of the approaches that have demonstrably improved the chances for success of the planned change and reduced reactive resistance is to let people in on the action—to participate in the decision-making process.[62]

Fraser also notes the five factors David A. Kolb and Richard E. Boyatzis identified as being most related to achieving a goal: awareness, expectation of success, psychological safety, measurability of the change goal, and self-controlled evaluation.[63]

VE is ideally suited to meeting these challenges. The following subsections describe the activities during the Implementation Phase.

1. Prepare a Written Report

The oral presentation of study results is helpful to the person who is responsible for making the decision; however, it should never replace the written report. A written report normally demands and receives a written reply, whereas an oral report can be forgotten and overlooked after it is presented. In the rush to conclude a project, promote a solution, or avoid the effort of writing a report, many proposals fail to materialize because the oral presentation alone is inadequate. The systematic approach of the VE job plan must be followed to conclusion and should include the meticulous preparation of a written report.

Like any other well-prepared report, this final report should

- Satisfy questions the decision-maker is likely to ask,
- Provide assurance that approval would benefit the organization,
- Include sufficient documentation to warrant a favorable decision with reasonable risk factors (both technical and economic), and

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62 R. A. Fraser, "The Value Manager as Change Agent or How to be a Good Deviant," in *SAVE International Annual 24th Conference Proceedings* (Sacramento, CA, May 6–9, 1984), 199–203. The acronym VA in the quote means value analysis—which is synonymous with VE.

63 David A. Kolb and Richard E. Boyatzis, "Goal Setting and Self-Directed Behavior Change," in *Organizational Psychology: A Book of Readings*, ed. David A. Kolb, Irwin M. Rubin, James M. McIntyre (Englewood Cliffs, NJ: Prentice-Hall, 1979).

- Show how performance is not adversely affected.

Well-prepared teams get a head start on the final report by documenting the progress between phases. For example, before the Development Phase, the team should develop documentation detailing what is proposed, to what extent the idea meets the criteria established in the Orientation Phase, risks, investment costs, expected savings, and so forth for each surviving idea.

The final report should be accompanied by a team letter that summarizes the recommendation and action plan and requests action from the sponsor. It should be sent with the report to all stakeholders.

2. Enhance the Probability of Approval

Approval of a proposal involves change to the status quo. Because of this or other pressing priorities, a manager may be slow in making a decision.

The manager who makes an investment in a VE study expects to receive periodic progress reports before a final decision is made. Regular reporting helps ensure top management's awareness of, support for, and participation in any improvement program. Therefore, the change should be discussed with the decision-makers or their advisors before and after the final report has been submitted. This practice familiarizes key personnel with impending proposals and enables a more rapid evaluation. Early disclosure can also serve to warn the originators of any objections to the proposal. This "early warning" will give the originators an opportunity to incorporate explanations and details into the final report to overcome the objections. These preliminary discussions often produce additional suggestions that improve the proposal and enable the decision-maker to contribute directly.

Implementation depends on an expeditious approval by the decision-makers in each organizational component affected by the proposal. The VE team members should serve as liaisons between decision-makers and other stakeholders by preparing information that weighs the risks against the potential rewards and by identifying potential roadblocks and solutions.

Some organizations convene an implementation meeting with all stakeholders.[64] Once tentative decisions are made, this meeting is used to help everyone understand which proposals or modified proposals have been accepted or rejected or will be studied further. In some cases, the tentative decisions are changed based on clarification of a misunderstood assumption.

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[64] Jill Ann Woller, "Value Analysis: An Effective Tool for Organizational Change," in *SAVE International 45th Annual Conference Proceedings* (San Diego, CA, June 26–29, 2005).

3. Monitor Progress

Implementation progress must be monitored just as systematically as the VE study. The VE team should ensure that implementation is actually achieved. A person could be given the responsibility of monitoring the deadline dates in the implementation plan and the process of obtaining any implementation funding.

4. Expedite Implementation

To minimize delays in the implementation process, the VE team should provide assistance, clear up misconceptions, and resolve problems that may develop in the implementation process. When possible, the VE team should prepare first drafts of the documents necessary to revise handbooks, the specifications, the change orders, the drawings, and the contract requirements. Such drafts help to ensure proper translation of the idea into action and serve as a baseline from which to monitor progress of final implementation. The VE team should review all implementation actions to ensure communication channels are open and that approved ideas are not compromised by losing their cost effectiveness or the basis for their selection.

5. Follow-up

The final activity of the Implementation Phase includes several diverse tasks that foster and promote the success of subsequent VE efforts:

- Obtain copies of all completed implementation actions,
- Compare actual results with original expectations,
- Submit cost savings or other benefit reports to management,
- Submit technical cross-feed reports to management,
- Conduct a “lessons-learned” analysis of the study to identify problems encountered and recommend corrective action for the next study,
- Publicize accomplishments,
- Initiate recommendations for potential future VE studies on ideas evolving from the study just completed,
- Screen all contributors to the effort for possible receipt of an award and initiate recommendation for appropriate recognition.

I. Concluding Comments

Although the job plan may seem intimidating, it is a proven technique for successfully using VE to address any problem. It usually involves a trained facilitator and can be tailored to individual circumstances. As with almost any decision-making

endeavor, the first and last phases are the most important. There are countless variations on how to conduct the analyses. In the first phase, determining the right problem and putting together the facts and the team to deal with it are critical. In the last phase, after a decision is made, following through on its implementation is essential. If the implementation is not successful, no savings will be realized.

7. VE from a Contractor's Perspective

The purpose of this chapter is to provide information and suggestions that can facilitate the successful development, preparation, submission, and implementation of VECPs to realize the benefits of VE for both the government and its contractors. It is not intended to make the contractor an expert on VE principles or techniques.[65]

As in all other contractual actions, it is extremely important to read the contract before developing VECPs. This review will acquaint the contractor with specific contract requirements and provisions and could also reveal non-value-added requirements/ provisions that add cost to the performance of the contract. These non-value-added requirements/provisions may themselves be appropriate targets for a VECP submittal if other VECP requirements are met (i.e., a change to the contract is required and the cost of performance could be reduced).

Contractors can obtain additional guidance from (1) the VE clause in their applicable contract; (2) FAR 52.248-1, including Alternates I, II, and III, which provide the basis for contractors to submit VECPs in supplies or services contracts;[66] or (3) their government contracting office. Personal assistance may be obtained from the government's VE advocate or from the overall DOD point of contact, as shown in the forwarding letter to this document.

This chapter is organized as follows: Section A identifies contractor considerations for the effective use of VE in government contracts. Provisions of the VE terms and conditions in contracts are briefly discussed in Section B. Sections C and D provide guidelines for preparing VECPs and for sharing VECP-generated savings, respectively.

While an untapped potential exists for flexibility and tailoring the FAR to accommodate the needs of the Federal Government and its contractors, extenuating

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65 This chapter was the basis of "Contractor's Guide to Value Engineering (Version 2.1)," May 2006. Army Pamphlet 11-3, "Value Engineering" (undated), and DoD Handbook 4245.8-H, "Value Engineering," March 1986, were original sources.

66 FAR 52.248-2 and FAR 52.248-3 apply to architect-engineer and construction contracts, respectively. For the most part, the material in this chapter applies to contractors across the board. For more information about architecture-engineer and construction contracts, see Engineer Pamphlet (EP) 11-1-4, *Value Engineering A Profitable Partnership*, May 15, 1995.

circumstances in today's contracting environment often add complexity to the VECP process and consequently discourage the use of VECPs.[67]

A. Establishing and Maintaining an Effective Contractor VE Program

A VECP is a proposal submitted to the government by the contractor in accordance with the VE clause in the contract. It proposes a change that, if accepted and implemented, provides an overall cost savings to the government. A VECP may update an existing design to the current state-of-the-art technology, simplify complex material by modifying or eliminating components, update specifications/drawings to provide improved data for future procurements, or reduce Contract Data Requirements List items, to name a few examples. Despite the term, "value engineering," no engineering effort is required; only a proposal that reduces the cost of performance under the contract and requires a contract change for implementation. The VE terms and conditions in a contract prescribe that the contractor receives a substantial share in the savings accrued as a result of implementation of the change.

There is a mistaken belief that a VECP requires a change in a specification. It does not; it requires only a change in the contract. To qualify as a VECP and to ensure that savings can be shared, the proposed change must be submitted under a current contract and must meet two primary requirements:

1. It must require a change to the contract under which it is submitted.
2. It must provide an overall cost savings to the government after being accepted and implemented. (Note that a VECP could result in increased unit cost but reduced O&S cost. Thus, there would be an overall savings to the Defense Department.)

As in the government, management support is necessary for successful contractor use of VE on government contracts. The following is a suggested listing of questions to help contractors determine whether they have the attitudes and disciplines needed to have a viable, effective VE program:

1. Does the company establish VECP goals?
2. Do VECP goals flow down the corporate structure?
3. Are contractor management personnel involved in VECP decisions and do they approve VE operating goals and budgets?

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[67] See Jay Mandelbaum and Danny L. Reed, *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046 (Alexandria, VA: Institute for Defense Analyses, October 2006) for more information.

4. Do contractor management personnel consult with key government personnel on the use of VECPs as a cost-reduction tool and gain government agreement on the need to apply the VE methodology to the system being acquired?
5. How do contractor personnel benefit from contributions to approved VECPs? Are there special awards and/or recognition?
6. Do contract negotiators understand the FAR VE provisions?
7. Are VE sharing provisions, as a matter of company policy, in subcontracts?
8. Does the company's accounting department identify VECP income separately so that:
    a. Management personnel can recognize the monetary benefit of VE?
    b. Management can be kept informed of expenditures and receipts resulting from the VE effort?
9. Are resources assigned specifically for the development of VECPs?
10. Does the company work to minimize the time to:
    a. Develop a VECP?
    b. Obtain internal approval before submitting a VECP to the government?
11. Does the company conduct formal VE workshops to expand in-house capabilities?
12. Is there a VE training and indoctrination program?
13. Is there coordination between government contract administration and the company's marketing efforts with respect to VECPs?

B. VE Terms and Conditions in Contracts

The basic VE provision is the VE Incentive (VEI) clause in the FAR. The VEI clause is included in most supply/service contracts when the contract price exceeds $100,000. It may also be included at lower thresholds. For example, using the clause for spares/repair kit contracts over $25,000, if the contract is not for standard commercial parts, is a common practice among many DOD organizations. The VEI clause may be included in contracts under $100,000 if the contracting officer sees a potential for significant savings. If the VEI clause is in the contract, contractor participation is voluntary. However, when contractors do participate in the VE program by originating, preparing, and submitting VECPs, they will be rewarded for their (and any of their subcontractors') ideas if the ideas are adopted by the procuring activity. The sharing rate (percentage of the savings) received by the contractor is specified in the FAR.

In addition to the basic VEI clause, the FAR contains alternative provisions that can be incorporated into a contract that requires a mandatory VE effort by the contractor. Known as the VE Program Requirement (VEPR) clause, it may be included in initial production solicitations and contracts for major programs if the contracting officer determines that significant savings may result from a sustained, specified VE effort. Typically, solicitations and contracts employing a VEPR include a Statement of Work, a Contract Data Requirements List requirement to submit VECPs, and a separate Contract Line Item. The VEPR clause can be used as a risk-sharing mechanism where the parties to the contract may agree to share development costs. Unfortunately, the use of the VEPR has declined in the Department due to the extensive amount of government preparation and oversight that is required to manage it.

1. When No VE Provisions Are Included in the Contract

It is possible that a contractor could have an idea for a VECP but has a contract containing no VE provisions. In this case, the contractor should notify the Procuring Contracting Officer (PCO) that it would like to submit a VECP. The contractor should request that a contract modification be issued as soon as possible to incorporate applicable FAR provisions. Normally, VEI provisions will suffice. However, if the contractor's idea will require significant initial funding and the marketing/pre-sell efforts have indicated that the government is interested, the contractor may request the VEPR provision.

2. Subcontractor VE

The FAR requires prime contractors to extend VE provisions to their subcontractors on contracts of $150,000 or greater.[68] It is recommended that VE provisions should also be extended to subcontractors on contracts of lesser value unless the nature of the work precludes VE benefits. A subcontractor must submit its VECP to the prime contractor who, in turn, submits it to the government.

3. VE and Performance-Based Contracts

Recent changes to promote acquisition excellence have mandated the increased use of performance-based contracts. Some believe that performance-based contracting is eliminating the contractor's incentive to submit VECPs because under a performance-based contract, contractors can make changes without government approval and keep all the savings. There are, however, a number of reasons why a contractor would submit a VECP and share the savings with the government. In situations where there are high

[68] Construction contracts encourage the contractor to have a VE clause in any subcontracts totaling $65,000 or more.

development and implementation costs, new or risky technologies, changes that require government test facilities, or changes that affect the acceptance of products, it is mutually beneficial for contractors to submit (and the government to accept) VECPs. Without VECPs, the contractor would most likely refrain from any investment because of the risks involved. In addition, even in a performance-based contract, there are still some areas that remain under government control for which VECPs may be submitted. Finally, in a contract where cost and pricing data may be collected, often it is beneficial for a contractor to submit a VECP to secure a share of future savings that otherwise would be negotiated away as general efficiencies.

C. Preparing Value Engineering Change Proposals (VECPs)

VECP preparation encompasses marketing the idea, gaining informal government approval, developing the required information, and formal submission.[69]

1. VECP Marketing

VE clauses in DOD contracts are not enough. The clauses merely invite or require contractors to question the value of government specifications, statements of work, and those requirements that contribute nothing (except cost) to the contract tasks or items being acquired.[70] Both parties (the government and the contractor) must work together to capture the actual benefits of VE efforts.

As with any change to an active contract, communication between the contractor and the approving authority is critical because a VECP is a change to the contract and thus a change to the program. A program manager's primary concerns are schedule, performance, and cost. Any change that could have an impact on any of these areas requires early discussion and general agreement from all parties involved, including the Procuring Contracting Officer (PCO) and the Administrative Contracting Officer (ACO) for the particular contract.

Because the cost of preparing a formal VECP is often quite substantial, the contractor needs to pre-sell or market the VE idea. Pre-selling enables the contractor to get from the government an indication of whether a potential idea should be pursued. The contractor should get to know the government point of contact/government VE advocate

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69 Chapter 12, Section B, provides additional information on these subjects in the context of a VE community of practice.

70 Although certain contractual requirements such as Contract Performance Reports, Cost and Software Data Reports, Integrated Master Schedules, and Contract Funds Status Reports may not seem to add value from the contractor's standpoint, they convey valuable management and financial information to the Government, are required by regulations, and cannot be waived in the course of value engineering.

who has the responsibility for evaluating and accepting/approving the VECP. A potential VE idea should be presented as early as possible to the appropriate points of contact.

This informal submission may take the form of a slide (or other) presentation that describes and details the technical aspects of the idea, lists its advantages and disadvantages, estimates the cost to implement and the potential cost savings, and meets as many of the eight minimum requirements of paragraph (c) of FAR 52.248-1 as possible. A contractor is not required to make an informal submission, but doing so is likely to improve the contractor's chances of success, especially if the development of the idea presents the possibility of significant risk to the contractor or the program. This presentation can help the government determine whether the idea deserves additional consideration or should be abandoned. If the government is receptive to the idea, the contractor can request the government's views on qualification and testing requirements as well as other government cost impacts. The contractor should be aware that the government's validation that the preliminary proposal has potential to be accepted as a VECP does not guarantee that the VECP will be accepted or approved, nor does it guarantee ownership of the idea. Also, the government's favorable response does not obligate the contractor to submit a VECP, nor does it obligate the government to pay for effort already expended on the VE initiative.

While a preliminary, informal submission does not eliminate all risk to the contractor, it reduces one major element of contractor risk by preventing a contractor's expenditure of significant funds and time on ideas that have little or no chance of being accepted or approved. In rare cases of concurrent competitive contract efforts, an independent formal submission of a VECP from a competitor may preempt the favorable consideration of a preliminary proposal. The government is prohibited from unilaterally "using" a contractor's VECP idea or sharing it with a competitor, but there is no prohibition on competitors independently pursuing similar efforts and making independent formal submissions.

The contractor should also be aware that an informal submission does not establish ownership of a VE idea or the right to share in any resultant savings. This ownership is established only when a fully documented, formal VECP is submitted.

In summary, preliminary submission of ideas for a VECP is advantageous to the contractor because:

- It establishes a "date of record" for contractor development costs incurred in preparation of the VECP.
- It reduces the risk of expending time, effort, and funds on an idea that the government does not want to pursue.

2. Basic Requirements of the Formal VECP

When the contractor makes the decision to submit a VECP, those responsible for preparing it should realize that the chance of the VECP being approved is proportional to the completeness of its preparation. Sufficient information must be provided so that the government can conduct a thorough evaluation within a reasonable amount of time. Failure to provide adequate data will usually result in a request for additional data (which significantly delays the process) or could possibly result in the VECP being rejected. The contractor should prepare a VECP using an approach similar to responding to a formal procurement solicitation. The following is the minimum information required for a VECP submission according to FAR 52.248-1:

1. A description of the difference between the existing contract requirement and the proposed requirement, the comparative advantages and disadvantages of each, a justification when an item's function or characteristics are being altered, the effect of the change on the end item's performance, and any pertinent objective test data.
2. A list and analysis of the contract requirements that must be changed if the VECP is accepted, including any suggested specification revisions.
3. Identification of the unit to which the VECP applies.
4. A separate, detailed cost estimate for (i) the affected portions of the existing contract requirement and (ii) the VECP. The cost reduction associated with the VECP shall take into account the Contractor's allowable development and implementation costs, including any amount attributable to subcontracts under the Subcontracts paragraph of this clause.
5. A description and estimate of costs the government may incur in implementing the VECP, such as test and evaluation and operating and support costs.
6. A prediction of any effects the proposed change would have on collateral costs to the agency.
7. A statement of the time by which a contract modification accepting the VECP must be issued in order to achieve the maximum cost reduction, noting any effect on the contract completion time or delivery schedule.
8. Identification of any previous submissions of the VECP, including the dates submitted, the agencies and contract numbers involved, and previous government actions, if known.

a. Format of the Formal VECP

The FAR clause relative to VE does not specify a particular format to be followed in preparing a VECP. Configuration management should be performed in accordance with the terms of the contract. Any questions should be directed to the government contracting officer.

b. Where to Send VECPs

The FAR governs the distribution of VECPs. The clauses for supply/service contracts require that VECPs be submitted to the PCO and to the ACO when the contract is administered by other than the Defense customer (e.g., Defense Contract Management Agency). Copies should also be sent to the appropriate Program Office and to the government VE Office and/or VE advocate, as appropriate.

The government VE advocate monitors all VECPs received and, through close coordination with the PCO and Program Office, facilitates timely processing. The government VE advocate can also serve as a point of contact from which the contractor may obtain the status of the VECP.

c. Transmittal Letter

Preparation of a transmittal letter forwarding the VECP is also a important step toward success. The transmittal letter should state that the VECP is being submitted pursuant to the VE provisions of the contract. The transmittal letter should also serve as a summary of the contents of the VECP and should briefly state the nature of the proposed change, estimated price changes, and reference where complete details can be found in the proposal. The transmittal letter serves as a table of contents of the proposal and as a marketing document, highlighting the proposal's technical advantages and overall cost reductions to the government.

d. Restricting Data

Normally, the government has unlimited rights to use the data in a VECP. If a VECP contains information that the contractor wishes to restrict from use prior to government approval, the contractor should include an appropriate legend on each page of the VECP. The FAR clause 52.248-1 language for supply/service contracts for this legend is as follows:

> These data, furnished under the VE clause of Contract No. _____, shall not be disclosed outside the Government or duplicated, used, or disclosed, in whole or in part, for any purpose other than to evaluate a VECP submitted under the clause. This restriction does not limit the Government's right to use information contained in these data if it has

been obtained or is otherwise available from the contractor or from another source without limitations.

If the VECP is accepted, however, the government normally has the right to use any and all data contained in the VECP and its supporting documents.

If the VECP contains proprietary data that the contractor wishes to restrict even after acceptance of the VECP, a statement to that effect must be included in the VECP. The proposal should be marked with the appropriate limited rights legend from the "Rights in Technical Data and Computer Software" clause of the DOD FAR Supplement, and the contractor must explain in the proposal the basis for asserting limited rights. The contract modification implementing the VECP should specify the limited rights that the government has accepted. The contractor should realize, however, that a VECP that results in a "sole source" condition for future acquisitions might not be as readily accepted as one for which this restriction is not imposed.

3. Additional VECP Guidelines

The following additional guidelines apply when preparing VECPs:

- When a contractor submits a VECP for approval, the contractor should not initiate action to implement the change until the contractor receives a formal contract modification approval from the government.
- When a contractor submits a VECP, the contractor should identify other similar or related contracts to which the VECP may apply (if known). The contractor should identify the potential to have other program customers participate in the VECP nonrecurring cost (e.g., foreign military sales customers).
- When a contractor undertakes a VECP effort, the contractor must keep records of development costs and require that subcontractors do the same.
- Contractors should be as accurate as possible in calculating implementation costs and insist that the government provide accurate and complete data when calculating government implementation costs.
- When a VECP is incorporated into the contract(s), the contractor should maintain internal records identifying the first delivered item containing the VECP.
- The contractor may withdraw the VECP in whole or in part prior to acceptance/rejection. However, any withdrawn VECP or portion thereof, may be subsequently incorporated into the contract without payment of a share of the cost savings to the contractor. This mechanism helps preclude a possible situation where the contractor, not satisfied with the contracting officer's determination of the worth of a VECP and the associated share in cost savings,

withdraws the idea to place the contracting officer in an unfair negotiating position.

D. Sharing VECP Savings

The Department of Defense has been encouraging submission of VECPs since the VE policy was first established in the FAR. Many changes that have occurred over the years have clarified the FAR language and increased the contractor's share of savings.

Acquisition and collateral savings are two basic types of savings that can be shared when a VECP is approved and implemented under a supply/service contract. Subsections 1 and 2 describe the sharing arrangements for firm-fixed-price contracts with VEI provisions and Subsection 3 discusses sharing arrangements with subcontractors. Sharing arrangements vary with other types of contracts. FAR Part 48 and 52.248-1 define the terms used in VE, the criteria for VECP acceptance, and recommending approval of sharing arrangements. In addition, incentive contracts may contain special provisions to ensure that no adjustments are made to targets or ceilings when a VECP is approved. This results in instant contract VECP savings being rewarded under the overall contract cost incentive. Whatever the type of contract, it is the government's intent to offer a full range of motivational VE options to contractors while precluding duplication of incentives.

1. Acquisition Savings

The FAR defines *acquisition savings* as "savings resulting from the application of a VECP to contracts awarded by the same contracting office or its successor for essentially the same unit." Acquisition savings may include savings obtained on the instant contract, concurrent contracts, and future contracts.

The instant contract is the contract under which the VECP is submitted and accepted. As the VECP is implemented on items delivered under this contract, the contractor will receive a percentage share of the net savings that accrue as a result of the VECP. In calculating these savings, the contractor's (and, if applicable, subcontractor's) reasonable, allowable, and allocable costs for development and implementation of the VECP and the government's costs for implementation are all taken into consideration. A contractor's development costs are those costs incurred in developing, testing, preparing, and submitting the VECP. Development costs materialize after it has been determined that a VECP will be prepared and before acceptance of the VECP by the government. Implementation costs are those costs resulting from contractual changes required as a result of Government acceptance of the VECP. Implementation costs are incurred after the VECP has been approved. For audit purposes, the contractor must identify and record those costs incurred (including subcontractor costs). In calculating any adjustment in this contract's price for instant contract savings (or negative instant contract savings), the

contractor's allowable development and implementation costs include any subcontractor's allowable development and implementation costs and any VE incentive payments to a subcontractor that clearly result from a VECP accepted by the government under this contract. The contractor may choose any arrangement for subcontractor value engineering incentive payments, provided that the payments do not reduce the government's share of concurrent or future contract savings or collateral savings. The arrangements negotiated for the instant contract are continued in future contracts, including any negative instant contract savings for the contractor submitting the VECP to the government.

Concurrent contracts are those contracts that the VECP originator (referred to as Contractor A) and other contractors (Contractors B, C, etc.) have ongoing at the time the VECP is approved for essentially the same item. If the government directs that Contractor A's VECP be incorporated into Contractor B or C's contract, then Contractor A will receive a share of the net savings obtained from contracts B or C (any contract affected by Contractor A's VECP). Contractor A's instant contract total price will then be increased by that amount.

Acquisition savings can be shared in one of three ways. If the government can predict with some degree of certainty the number of affected items to be procured within the share period (and this number is not classified), the "lump-sum" method of settlement can be used if the contractor and the contracting officer so agree. The contract modification incorporating the VECP will specify the anticipated future procurement quantity. The cost savings per unit are then multiplied by the anticipated share period quantity, and the instant contract price is increased by the contractor's share of that amount.

The primary way of sharing future savings is for the contractor to receive a portion of the per-unit savings that occur either as contracts incorporating the VECP are awarded or as VECP-affected units are delivered. This sharing applies to items scheduled for delivery within the determined share period (as described in the FAR), which begins upon acceptance of the first item affected by the VECP. In the case of multiyear contracts, sharing applies only to quantities that (1) are fully funded at the time of VECP acceptance, and (2) fall within the determined share period. It is the contractor's responsibility to maintain records from the time the first VECP-affected unit is accepted until the determined VECP share period ends. Whenever the government issues a new contract during this share period for essentially the same item, and the contractor's VECP has been incorporated into the contract documents, the contractor is entitled to a portion of any per-unit savings during the share period. Payment will be made via the instant contract when savings are realized. Normally, the savings per unit calculated for the original contract will be multiplied by the number of units scheduled for delivery before expiration of the share period. Also, in design or low-rate initial production contracts, the

government may modify the usual VE clause to improve contractor incentives. If the clause is so modified, the sharing formula is expressed in terms of a specific quantity and not in time. This quantity is the number of units affected by the VECP that are scheduled to be delivered over a period between thirty-six and sixty consecutive months (set at the discretion of the contracting officer for each VECP as described in the FAR) that spans the highest planned production, based on planning and programming or production documentation existing at the time the VECP is accepted.

The third way of sharing savings with the contractor is the "no-cost modification" method. Under this method, the contractor keeps all savings from the instant contract and its own concurrent contracts. The government keeps all savings from future contracts and concurrent contracts with other sources as well as all collateral savings. This method, if agreed upon by both the government and the contractor, can minimize the administrative costs of determining and negotiating savings.

If the "lump-sum" method or the "no-cost settlement" method cannot be mutually agreed upon, then the future per-unit savings method will be used.

2. Collateral Savings

Collateral savings are those measurable net reductions in cost of operation, maintenance, logistics support, shipping, or Government Furnished Equipment that result from an accepted VECP. In some situations, a VECP might increase the acquisition cost of an item but result in substantial collateral savings. For collateral savings, the contractor is entitled to 20 to 100 percent (determined by the contracting officer as described in the FAR) of the savings that the government estimates will be realized during an average 1-year period. However, the contractor's share can not exceed $100,000 or the value of the instant contract, whichever is greater. The government determines the amount of collateral savings. Some contractors have had several VECPs approved and implemented with substantial collateral savings. However, determining and verifying measurable net reductions can be difficult and, in some instances, the government may exclude the collateral savings program.

3. Sharing Savings with Subcontractors

As discussed previously, the prime contractor's allowable development and implementation costs include any subcontractor's allowable development and implementation costs and any VE incentive payments to a subcontractor that clearly result from a VECP accepted by the government under this contract. The contractor may choose any arrangement for subcontractor VE incentive payments provided that the payments do not reduce the government's share of concurrent or future contract savings or collateral savings.

Prime-to-subcontractor VE arrangements can be made by the prime contractor extending to the subcontractor any or all of the instant contract savings and/or a percentage of whatever amount the prime contractor receives as its share of concurrent contract share, collateral share, and future acquisition share. For example, a simple paragraph could be included in a subcontract to provide a 50 percent share of whatever dollar amount the prime contractor receives in the four areas of sharing on a successful VECP.

The sharing between prime contractor and subcontractor can be a matter of negotiation between them and should provide motivation for the subcontractor to submit VECPs to the prime contractor. It should also provide a fair share to the prime contractor, who is responsible for putting a subcontractor's VECP into proper format and "selling" it to the government. Any development and implementation costs incurred by the subcontractor, and the share of instant contract savings extended to the subcontractor, are considered to be a part of the prime contractor's development and implementation costs.

E. Concluding Comments

Because VE is the only incentive program with a predefined means for contractor sharing in savings, it represents a valuable means of increasing a contractor's margins, while also providing savings to the Defense Department. The success achieved is proportional to the resources invested in the effort. Having a formal VE program to establish policies for promoting VE with subcontractors, market VE, and provide guidance regarding the basic requirements of submitting a VECP will increase a contractor's success.

8. VE Synergies with Diminishing Manufacturing Sources and Material Shortages

This chapter describes important synergies between VE and diminishing manufacturing sources and material shortages.[71] Section A provides an introduction to DMSMS. Section B shows the basis for drawing parallels between the VE methodology and the steps in the DMSMS risk management process. Examples of the synergies are shown for several DMSMS resolution options in Section D.

A. Introduction to DMSMS

DMSMS is defined as the loss or impending loss of manufacturers or suppliers of items or raw materials. DMSMS is a complex issue with at least three basic problems to be addressed:

- **Technology improvements:** As new products are developed, the technology used in predecessor products becomes outdated, making it more difficult to maintain the older equipment.
- **Decreasing demand:** The parts needed to repair products may become more difficult and expensive to acquire because fewer are produced as demand for them decreases.
- **Non-availability of materials:** The materials required to manufacture products may no longer be available, or they may be expensive to procure.

As products evolve, they require different processes, parts, and technology than their predecessors; however, the earlier versions still need to be maintained throughout their life cycles. As new products become more prevalent fewer parts are available to fix the older versions as the technology, manufacturing processes, and materials become outdated. This is especially true for commercial-off-the-shelf (COTS) parts. Commercial parts availability and performance are dictated by the non-military market. The amount of time between military program development initiation to completion of production and support in the field leads to greater numbers of DMSMS problems when using COTS.

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[71] The material in this chapter was extracted from Jay Mandelbaum, Royce R. Kneece, and Danny L. Reed, *A Partnership between Value Engineering and the Diminishing Manufacturing Sources and Material Shortages Community to Reduce Ownership Costs*, IDA Document D-3598 (Alexandria, VA: Institute for Defense Analyses, September 2008).

DMSMS is closely related to Performance-Based Logistics (PBL), which is a strategy that places primary emphasis on optimizing weapon system support to meet the needs of the warfighter. PBL specifies outcome performance goals of weapon systems, ensures that responsibilities are assigned, provides incentives for attaining these goals, and facilitates the overall life-cycle management of system reliability, supportability, and total ownership costs. It is an integrated acquisition and logistics process for buying weapon system capability. Generally, PBL contracts are long-term (five to fifteen years) and require that the provider manage many aspects of product support throughout the life cycle. A properly structured PBL strategy incentivizes the provider to maintain a proactive DMSMS management program to achieve the required performance outcome(s) without adversely affecting total ownership cost.

According to DMSMS guidance, managing DMSMS follows a standard sequence: [72]

- **Identify.** Identify "problem" parts in the line replaceable units (LRUs) or weapon replaceable assemblies (WRAs) that are obsolete, or will be in the foreseeable future. Quick and concise communication among all stakeholders when a DMSMS case first occurs is part of this step. If DMSMS management is being done in a reactive mode, communication may be all that can be done. A notice by a supplier of plans to discontinue a part may be the only warning of a DMSMS issue. However, a proactive DMSMS risk management process requires more. *Potential* DMSMS concerns should be continuously monitored so they can be identified and mitigated long before it is necessary to "sound the alarm." This implies keeping track of materials and suppliers to anticipate issues—a monumental task in a big weapon system. Although vendor "surprises" cannot be completely eliminated, such an approach maximizes the time to react.
- **Assess.** Considering the population of problem parts, determine and prioritize the LRUs/WRAs most at risk for current and future DMSMS impacts. This step develops an understanding of the scope and extent of the pending issue from a demand perspective. Facts are gathered so that a sound decision on the appropriate DMSMS resolution option can be determined. Data such as the systems affected and estimates of the demand per system for the part in question must be obtained. Demand is usually estimated on the basis of historical usage. Sometimes these estimates may accurately reflect future usage, but in other cases, where, for example, the effects of an obsolete design cause conditions to change, historical estimates may not be a good predictor. Therefore,

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[72] SD-22, *Diminishing Manufacturing Sources and Material Shortages—A Guidebook of Best Practices and Tools for Implementing a Proactive DMSMS Management Program*, September 2010.

understanding the sources of variance and developing both optimistic and pessimistic estimates are helpful.

- **Analyze.** Research the problem parts in the high-priority LRUs/WRAs first and, for each LRU or WRA, develop an optimum set of DMSMS solutions. DMSMS guidance discusses options ranging from encouraging the existing source to continue production to using Defense Production Act authorities to maintain a domestic source of supply. Case-specific analyses must be conducted to determine the most effective option or combination of options to mitigate the situation. A great deal of data for the item(s) in question is needed to support this effort.
  - The nature of the supply shortage,
  - When production is expected to stop,
  - The willingness and ability of the supplier to work with DOD in developing mitigation actions,
  - The availability of a technical data package, and
  - The roles of other pertinent contractors (e.g., a PBL provider).

  Information about alternatives is also needed. For example, the following questions should be answered along with an indication of the associated costs, risks, and schedule:
  - Are there any alternative sources?
  - What would be required to develop an alternative source?
  - Is there a known substitute?
  - Can a substitute be designed?
  - Is a life-of-type purchase a feasible solution?
  - What are the interface requirements?
  - What kinds of testing and qualification activities are necessary?
  - What are the field logistic support issues with alternate components and/or a redesign?
  - Is the redesign of a higher-level assembly feasible and desirable?
  - Can a needed system performance enhancement be achieved by a DMSMS redesign?
- **Implement.** Budget, fund, contract for, schedule, and execute the solutions for the high-priority LRUs/WRAs. The final step in the process is implementation.

Based on the results of the options analysis step, pros and cons will be developed for different alternatives. Recommendations should then be presented to the decision maker. After a resolution alternative has been selected, implementation begins. Often, responsibilities for implementation will reside with different organizations. Therefore, careful coordination of activities is a necessity.

B. VE Methodology Relationship to the DMSMS Risk Management Process

Figure 8 shows the correlation between the phases of the VE methodology and the steps in the DMSMS risk management process. Both processes attempt to take a problem from identification through the implementation of a solution. However, there is a great deal of synergy between the two processes and less overlap than the figure implies.

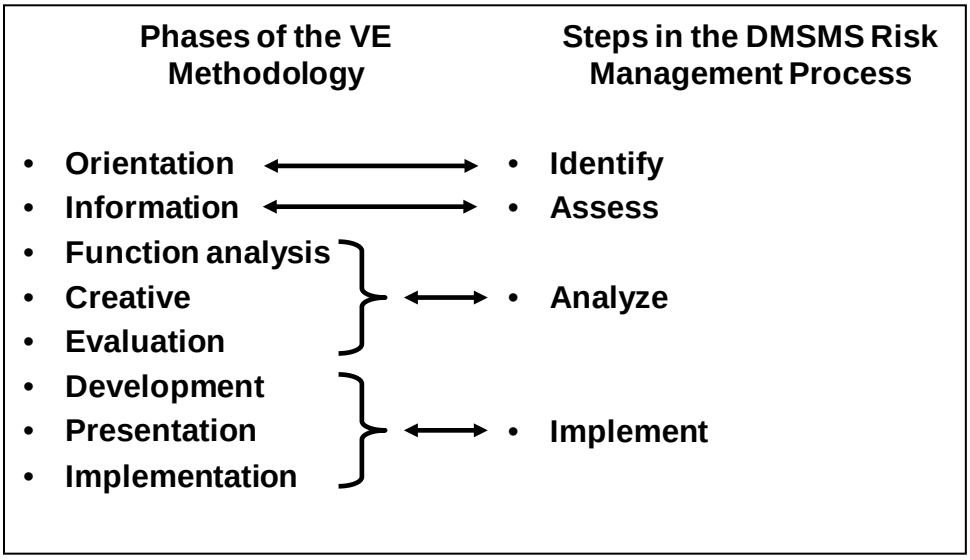

Figure 8. Correspondence between VE Methodology Phases and DMSMS Risk Management Process

VE is a problem-solving discipline. As such, organizations use VE practitioners to help determine solutions to the process and product-related issues they face. Problem identification is the critical first phase of the VE methodology. DMSMS represents a class of problems common to acquisition and logistics organizations. DMSMS problems provide opportunities to use VE-derived solutions.

The DMSMS 'assess' step and the VE Information Phase are similar; they both finalize the scope of the problem. However, the VE methodology has the potential to enhance the DMSMS approach. While DMSMS efforts are more ad hoc, the VE methodology is usually applied by a study team in a structured workshop environment.

Therefore, the VE Information Phase also begins building cohesion among study team members. This environment leads to a working relationship more conducive to finding optimal solutions to problems.

The DMSMS 'analyze' step has the same objectives as the VE Function Analysis, Creative, and Evaluation Phases. Once again, the use of VE may enhance these efforts by adding structure, robustness, and rigor to the process. Function analysis is a comprehensive technique for dissecting a problem into its most basic elements and then methodically determining the most beneficial areas for further analysis. Creative brainstorming in a professionally facilitated environment leads to the largest possible number of resolution ideas to be evaluated.

Finally, the VE Development, Presentation, and Implementation Phases correspond to the DMSMS 'implementation' step. While these activities are somewhat routine, VE provides its own unique and flexible implementation options.

C. Examples of VE Application to DMSMS Resolution Options

VE can make a significant contribution to DMSMS in several ways. By incentivizing government participants and their industry partners to increase their joint value proposition in achieving best value solutions as part of a successful business relationship, VE provides businesses with a strong profit-based incentive for using its skilled engineering workforce to mitigate DOD's DMSMS issues. Through the concept of shared savings, VE rewards contractors for making investments in DMSMS resolution options. In addition, the use of VE allows DOD to spread non-recurring engineering costs over time, making them far easier to fund. Finally, the creative elements of the VE methodology are designed to elicit innovative approaches to problem solving that might not otherwise be considered.

The benefits of applying VE to DMSMS issues are realized regardless of the DMSMS management approach being taken. The use of the VE methodology typically leads to innovative solutions that can be rapidly put in place.

When a program takes a proactive approach to DMSMS, a better solution can be achieved more quickly. While a PBL contract normally makes the contractor responsible for DMSMS planning and management, the contractor is not incentivized to look for the best value solution for the government. Use of PBL does *not* obviate the need for VE. For example, if the PBL contract is for time and material, the government will pay for the resolution of the problem. Without VE, the contractor will select an approach that optimizes its profit and minimizes its risk from the current PBL contract. That may mean that the contractor will take actions to maximize the availability of supply regardless of cost. If the PBL contract is fixed price, the contractor will take a similar approach because future years (which are awarded as contract options) are not normally priced. VE

changes the business case by providing the proper incentives for the contractor to adopt an approach more beneficial to the government in the long term. Also VE is more likely to find solutions with other collateral benefits because its methodology is designed to identify a broad range of potential solutions that have impact beyond the immediate problem at hand.

The DMSMS guidance describes numerous DMSMS resolution options. This section discusses several important ones—existing stock, reclamation, existing substitute, aftermarket, reverse engineering, and redesign. The subsections that follow describe how VE can enhance these DMSMS resolution options. In every case, real examples are given of how VE was used to find another way to acquire expensive, hard to obtain parts in the same way that DMSMS approaches look for alternative ways to acquire potentially unavailable items or materials.

1. VE Contributions to an Existing Stock Approach

In an existing stock solution to a DMSMS problem, the *current* supplier (1) utilizes *on-hand* inventories or (2) agrees to continue to produce the item in question. The following paragraphs discuss the former, i.e., on-hand inventories, first where a large quantity purchase is made in one of two ways:

- A life-of-type purchase procures a sufficient quantity of the DMSMS part to support full production plus repair for the expected life cycle of the system.
- A bridge purchase procures enough of the DMSMS item to meet demand until another solution is implemented.

While this option is often used, there are drawbacks associated with it. Costs for material management including packaging, storage, transportation, shelf life, and upkeep of the inventory must be considered. In addition, it is difficult to estimate demand accurately, especially for a life-of-type purchase. Frequently, items are retained in the operational inventory well beyond their originally expected life. When that occurs, the life-of-type purchase could be inadequate. On the other hand, if too many are purchased, there is waste associated with the excess inventory.

Value engineering has the potential to incentivize the contractor to perform the material management function and solves short-term budget problems associated with a quantity purchase, as shown in the following real example for radomes for the Standard Missile.

Navy Standard Missile Example of VE Contributions to DMSMS
Using an Existing Stock Resolution Option

The Standard Missile is a surface-to-air air defense weapon. Its primary mission is fleet area air defense and ship self defense and it has a secondary anti-surface ship mission. The radome is a dome that covers the radar on the outside of the missile. There are few radome suppliers because of the complexity involved in finishing them. Radomes must be capable of withstanding high heat and acceleration while allowing signals to penetrate without distortion.

Due to reduced program funding, the Navy halved its Standard Missile procurement rate. Radomes are a high-cost item with large lot charges under this particular missile program acquisition. If the radomes were to be purchased on the revised procurement schedule, the unit price would increase by 50 percent due to production slow down. Because radomes do not change, the Navy wanted to make a quantity purchase to reduce the overall cost. In that way, the radome supplier would be able to level load production to the quantities required for succeeding fiscal years. It would also optimize manufacturing setup time, allowing savings to be passed to the contractor. However, the Navy did not have the resources to pay for the quantity purchase in the current fiscal year.

The contractor had the latitude to use its own funds to make the quantity radome purchase without using the VE clause. However, there would be no likelihood for a return on investment, since, based on FAR pricing principles, the contractor would be required to sell them back to the Navy at the price paid. Meanwhile, the contractor would have incurred inventory holding costs and lost opportunity costs. Use of VE enabled the contractor to make the quantity purchase and sell future radome lots back to the Navy at the lower bulk-buy price, thus leading to significant savings.[73] This particular case led to a total savings of $1,153,500 shared equally by the contractor and the Navy.

Figure 9. Navy Standard Missile Example of VE Contributions to DMSMS
Using an Existing Stock Resolution Option

2. VE Contributions to a Reclamation Approach

A reclamation solution examines marginal or out-of-service equipment or supplies as a potential source of DMSMS parts. Another reclamation possibility is equipment that is in a long supply, perhaps as a result of a planned product improvement or modernization effort where baseline equipment could be cannibalized to address a DMSMS shortfall.

One potential drawback to reclamation is the condition of the reclaimed parts. They may be unserviceable or damaged. Also, unless very unusual circumstances (e.g., extremely low demand) surround the DMSMS issue, a reclamation effort probably represents only a short-term solution.

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[73] A mistaken belief is that a VECP requires a change in a specification. It does not; it requires only a change in the contract. The change could be a contract modification for a business arrangement authorizing the VECP and agreeing on sharing future savings without any technical change to the configuration baseline. That was the case in the radome example where the contract contained the former military standard on configuration management. As such, it required the VECP to be submitted on DD Form 1692, "Engineering Change Proposal." On Block 30 of the form, Configuration Items Affected, it listed, "None." On Block 31, Effects on Performance Allocations and Interfaces in System Specification, it listed, "This change will have no effect on the end item's system performance. This Value Engineering Proposal simply allows us to take advantage of the substantial cost savings obtained by the multi-year contract that [*the contractor*] has negotiated."

Value engineering can play an important role in making reclamation feasible; as demonstrated in the example below for the reclamation of M106 8-inch high-explosive artillery projectile scrap steel.[74]

Army Artillery Example of VE Contributions to DMSMS
Using a Reclamation Approach

The M795 is a 155-millimeter high-explosive artillery projectile with a high-fragmentation steel body. It provides increased effectiveness against major ground-force threats at greater ranges for anti-personnel and anti-materiel targets when compared to older 155-millimeter projectiles. Because of a world-wide scrap steel shortage, the M795 program contractor was finding it difficult to maintain a single source for M795 steel.

A VE study was initiated to develop a process to reutilize the steel from a large stockpile of surplus M106 8-inch projectile shells stored openly at McAlester Army Ammunition Plant. The steel could not be reclaimed directly since the projectiles contained trace amounts of explosives. The M106 projectiles were scheduled for demilitarization.

As a result of this study, a process was developed to decontaminate and mill the surplus M106 projectiles to reclaim the steel. This steel was then used as a constituent in the raw material for the manufacture of the M795 projectiles. M795 production costs were decreased because the cost of the process to provide the raw material needed for production was below the purchase costs on the open market. In addition to the benefits to the M795 program, this VE effort reduced the demilitarization stockpile, reduced demilitarization costs, and eliminated the hazardous open-storage of M106 projectiles at McAlester Army Ammunition Plant. Total cost avoidance savings in FY 2006 for the 197,000 projectiles processed amounted to $9.2 million.

Figure 10. Army Artillery Example of VE Contributions to DMSMS
Using a Reclamation Approach

3. VE Contributions to an Existing Substitute Approach

An existing substitute item is a different part that is *currently* being produced for a different application, perhaps by an alternate source. However, an existing substitute item is (or can be made) capable of performing fully (in terms of form, fit, and function) in place of the DMSMS item. In some cases, non-recurring engineering expenses will be incurred to achieve this. A drawback of this approach is that the resolution may be temporary if market conditions do not have a favorable outcome for the new source. In addition, expenses will have to be incurred for qualifying and testing the replacement item and the unit cost may be higher.

[74] This example was adapted from the Army's FY 2006 special VE award nomination.

Value engineering function analysis identifies viable options for items to be used as an existing substitute and incentivizes the prime contractor to invest in them. This area represents probably the most prevalent use of VE for DOD weapon systems. The following example illustrates the point.

Navy Phalanx Example of VE Contributions to DMSMS
Using an Existing Substitute Approach

The Phalanx Close-In-Weapon-System is a fast-reaction, rapid-fire 20-millimeter gun system that provides Navy ships with a terminal defense against anti-ship missiles and fixed-wing aircraft that have penetrated other fleet defenses. It can also be used against small gunboats, standard and guided artillery, and helicopters. Phalanx uses advanced radar and computer technology to locate, identify, and direct a stream of armor-piercing projectiles to the target. A contract was awarded to retrofit Phalanx with a manual controller to direct fire against targets of opportunity.

Using the function analysis aspect of the VE methodology, the contractor identified an opportunity to replace a military standard fixed-hand controller (similar to a joy stick) with a derivative of a commercial unit, not built to military standards. On its own initiative, the contractor worked with the commercial source to produce a modified unit and tested the unit against the requirements for the military standard version. Based on the test results, the contractor had confidence that the commercial derivative would meet all of the technical requirements at a lower cost. Therefore the contractor submitted a VECP to replace the standard military controller with ruggedized commercial derivatives. The military standard controller would cost $7,600, while the commercial derivative was only $2,100. Since each gun required three controllers, the net savings would be $16,500 per system. Approximately $2 million in savings were shared by the Navy and the contractor. Eventually, the Navy may save more than $9 million if the idea is applied to all ships. In addition, the VECP provided for earlier implementation of the improved system.

Figure 11. Navy Phalanx Example of VE Contributions to DMSMS
Using an Existing Substitute Approach

4. VE Contributions to an Aftermarket Approach

In a DMSMS aftermarket solution the original equipment manufacturer authorizes the assembly of an obsolete part. An aftermarket source for a product uses the drawings (or technical data package if available) and specifications provided by the original equipment manufacturer or prime contractor to produce an aftermarket version of the DMSMS part.

Aftermarket sources are a viable DMSMS solution because a smaller company might begin to produce an item that is no longer sufficiently profitable for a larger company. DOD is often able to reduce its costs by using aftermarket sources. With two or more suppliers, competition typically leads to lower cost. In addition, a smaller company (with lower overhead) may be able to produce an item less expensively than a larger company.

As was the case with substitute items, a drawback of this approach is that the resolution may be temporary if market conditions do not provide a favorable outcome for the new source. In addition, non-recurring engineering expenses will be incurred for building and testing the new line and ensuring part qualification and certification to meet requirements of form, fit, and function. Finally, the unit cost may be higher.

Value engineering enables the development of viable aftermarket sources. In the following example, an aftermarket source for the Air Force's Advanced Medium-Range Air-to-Air Missile (AMRAAM) Inertial Reference Unit (IRU) was developed from scratch based on the original requirements; interface constraints; form, fit, and function specifications; and help from the prime contractor.

Air Force AMRAAM Example of VE Contributions to DMSMS
Using an Aftermarket Approach

The AIM-120 Advanced Medium-Range Air-to-Air Missile is a fire-and-forget air-to-air missile capable of attacking beyond-visual-range targets. In the AMRAAM missile, the IRU accurately measures the missile vertical velocity and position enabling in-flight steering and targeting adjustments. Originally, there was only one source for this expensive item. The contractor was aware that others were interested in furnishing this item, so the contractor provided the requirements and helped encourage others in the development of the IRU.

In this example, the contract contained a mandatory VE program and the government recognized the value of having a second source for the IRU. Even though approximately $4 million in non-recurring engineering costs were required, the effort was well worth it. These efforts initially saved $2,000 per unit, but more importantly, without the addition of a second source through the VECP, the price of the IRU would have probably increased. The potential savings cannot be accurately estimated but are expected to be substantial.

Figure 12. Air Force AMRAAM Example of VE Contributions to DMSMS
Using an Aftermarket Approach

5. VE Contributions to a Reverse Engineering Approach

The reverse engineering resolution option seeks a producer to obtain and maintain the design, equipment, and process rights to manufacture a replacement item where no drawings are available. In this case, the new manufacturer uses the item itself to devise an approach to producing a copy of the original item with sufficient fidelity to meet form, fit, function and interface requirements. Reverse engineering discovers the design principles of the part by analyzing its structure, function, and operation. No support is provided from the original equipment manufacturer.

As was the case with substitute items, a drawback of this approach is that the resolution may be temporary if market conditions do not have a favorable outcome for the new source. In addition, non-recurring engineering expenses will have to be incurred for designing, building, and testing the replacement item and ensuring part qualification and certification to meet requirements of form, fit and function.[75] The new unit cost may be higher than the original item, and there may be issues of intellectual property rights.

[75] It should be noted that reverse engineering cost can be less than costs incurred in trying to manufacture an item from a technical data package (TDP). Often, manufacturing subtleties are not documented in the drawings or the TDP, or the TDP could be obsolete.

Value engineering function analysis identifies viable options for reverse engineering parts. The following example is based on a real VE application that has not been finalized. As a result, some details are omitted.

Missile Example of VE Contributions to DMSMS
Using a Reverse Engineering Approach

A defense missile contractor had a sole-source subcontractor for a costly warhead. The subcontractor was having problems meeting "insensitive munitions capability" requirements for the warhead to not explode in a fire or if dropped. With the cooperation of the government, the contractor submitted a VECP to develop an alternative, and less expensive, source for the warhead by reverse engineering. Since a different manufacturer is now being used, the performance of the warhead's insensitive munitions capability will also be improved since this manufacturer will use a different process for making the explosive portion of the warhead.

Approximately $12 million is being invested to develop the new source. Although savings of $15,000 per warhead is expected, the development of the second source makes this VE change and development of a second source even more valuable. Without the competition from another source, it was expected that the price of the warhead would have continued to escalate as it had in the past since the single source had no incentive to control costs.

Figure 13. Missile Example of VE Contributions to DMSMS
Using a Reverse Engineering Approach

6. VE Contributions to a Redesign Approach

As a resolution option, modification or redesign of the item is used to either eliminate the need for the part in question or replace it with another. Redesign may occur at many levels:

- The DMSMS part itself,
- The next higher level configuration item,
- An entire subsystem, or
- The end item itself.

Non-recurring engineering expenses for building and testing the new production capability and ensuring qualification and certification to meet requirements increase with the scale of the redesign effort. Minor redesign treats the DMSMS problem discreetly by redesigning only at the level needed to solve the immediate problem.

Value engineering function analysis identifies viable minor redesign options. Value engineering function analysis systematically identifies economically viable opportunities for major redesign when there is a high degree of interdependence. From a definitional perspective, it is sometimes hard to differentiate minor redesign from major redesign. The following example deals simultaneously with two somewhat *independent* parts of the Firefinder radar that were experiencing obsolescence issues.[76] On one hand, this example could be construed as a major redesign because of the scope of the combined effort involved. On the other hand, each part could have been dealt with as a separate minor redesign.

Army Radar Example of VE Contributions to DMSMS
Using a Redesign Approach

The AN/TPQ-37 Firefinder radar is designed for long-range detection and tracking of incoming artillery and rocket fire to determine the point of origin for counterbattery fire. The radar's legacy transmitter and radar processor were both experiencing issues with obsolescence and systemic failures. These failures hindered the radar's mission effectiveness and readiness in combat. Manpower and spare parts resources were required in large amounts to keep the systems maintained.

The Army conducted its own VE study to find alternative ways to perform the radar transmitter and processor functions. The study resulted in upgrading the radar with a redesigned electronic power amplifier module to replace the legacy transmitter and a new redesigned radar processor. Incorporating these new components improved the system's reliability, availability, and maintainability. These improvements provide large savings in operations and support costs, which far outweigh the costs to upgrade the radar. A 3-year cost avoidance of $102,784,600 was achieved.

Figure 14. Army Radar Example of VE Contributions to DMSMS
Using a Redesign Approach

D. Concluding Comments

VE is a systems engineering tool that employs a structured, innovative problem-solving methodology to reduce cost and improve quality and performance. It develops solutions by eliminating unnecessary functions and establishing new combinations of functions to be more responsive to the needs of the customer. Under DMSMS conditions, the resources required to perform a function are increasing, or are about to increase significantly. Therefore there is a high degree of commonality between the DMSMS risk management process and the VE methodology since VE systematically finds innovative solutions that reduce such costs and increase value.

More specifically, VE is an extremely powerful tool and methodology for (1) identifying a large number of resolution options; (2) evaluating their potential for solving the problem; (3) developing recommendations; and (4) providing incentives for the investments needed for successful implementation. Thus, using the VE methodology

[76] This example was adapted from the Army's FY 2007 VE award nomination for a team.

provides *greater opportunity* for developing and implementing innovative solutions to DMSMS problems.

As such, VE is ideally suited for use in resolving DMSMS issues. The DMSMS community identifies problems (ideally with plenty of lead time to determine a solution) and the VE tool develops solutions to those problems through function analysis. But the synergies are greater than this. The VE-enabled shared savings with the contractor is also a major factor. This concept provides the incentive necessary for the contractor to make investments that will mitigate DMSMS problems. For each DMSMS resolution option, there is evidence of significant benefits that can be achieved with the use of VE.

9. Value Engineering for Service Contracts

Most VE savings, especially those that are contractor initiated, are based on savings in the acquisition of hardware. However, the U.S. Government now spends its contract dollars predominantly on services. According to the U.S. Government Accountability Office, about 60 percent of the Federal Government's contract awards are for services. The U.S. Government acquires all types of services, ranging from routine commercial purchases of courier services, janitorial services, and services of security guards to highly skilled technical, scientific, and engineering services in support of space launches or the development of major weapon systems. FAR 48.201(a) requires that a VE clause (found in FAR 52.248-1) be included in all contracts for supplies and *services* exceeding a specified threshold.

A. Value Engineering Is Beneficial On Service Contracts

If *the unit price can be changed to reflect the VECP*, then a service contract would operate much the same as a hardware contract and produce similar benefits to both the government and the contractor.

1. Services Contract Example 1

The following simple example of a janitorial service contract in Table 2 demonstrates that the unit price can be calculated relatively easily for each of the Contract Line Item Numbers (CLINs) established. In this scenario, a building had extensive amounts of tiled floors that needed to be swept (daily at a rate of $60), mopped (weekly at a rate of $120), and waxed (monthly at a rate of $240) under a five-year contract (one year plus four option years).

Table 2. Janitorial Service Contract Example Before VECP Changes

Contract line item number (CLIN)	Requirement	Quantity	Unit	Rate	Total
0001	Sweep 15,000 sq. ft. of office space daily, Mon–Fri, for the 5-year period Oct 1, 20XX–Sep 30, 20XX	1,200	Days	$60.00	$72,000
0002	Mop 15,000 sq. ft. of office space weekly for the 5-year period Oct 1, 20XX–Sep 30, 20XX	250	Weeks	$120.00	$30,000
0003	Wax and polish 15,000 sq. ft. of office space monthly for the 5-year period Oct 1, 20XX–Sep 30, 20XX	60	Months	$240.00	$14,400
	Total				$116,400

A contractor could propose to replace the tile with carpet and show a net savings in upkeep over a period of time. The carpet would have to be vacuumed weekly at a rate of $120 and shampooed twice per year at a rate of $300. While there would be an initial investment for installation of the carpeting, the savings in cost of upkeep could result in significant savings over the length of the instant contract and the 4 option years. Table 3 shows the assumed results of the VECP changes.

Table 3. Janitorial Service Contract Example After VECP Changes

CLIN	Requirement	Quantity	Unit	Rate	Total
0001	Purchase and install 15,000 sq. ft. (1,667 sq. yds.) of industrial strength carpeting	1,667	Sq. Yd.	$20.00	$33,340
0002	Vacuum 15,000 sq. ft. of office space weekly for the 5-year period Oct 1, 20XX–Sep 30, 20XX	250	Weeks	$120.00	$30,000
0003	Shampoo carpet twice yearly for a 5-year period Oct 1, 20XX–Sep 30, 20XX	10	Each	$300.00	$3,000
	Total				$66,340
	Net Savings ($116,400 – $66,340)				$50,060
	Contractor Share of Savings Using a 50/50 Share ($50,060 × .5)				$25,030
	Revised Total				$91,370

In this hypothetical example, the government saves more than 20 percent of the three-year price, while the contractor's profits are increased by its share of the savings.

Without VE, the change (and the savings) would be less likely to occur since it would be difficult to obtain funds for the $33,340 investment—which by itself is more than the one-year funding in the instant contract.

2. Services Contract Example 2

The following hypothetical assumes a three-year contract (a base year plus two option years) for the professional services of a physician to give full physicals for $100 each to 3,600 military personnel each year—10,800 in total over three years. The associated contract requirements are reflected in Table 3.[77]

Table 4. Medical Service Contract Example Before VECP Changes

CLIN	Description	Quantity	Unit	Unit Price	Total Price
0001	Provide a complete annual physical to military personnel	10,800	EA	$100	$1,080,000

Since most of the military people are in excellent physical condition and the majority of personnel are young, the contractor could propose a VECP for a modified physical plan. Under the plan, anyone under twenty-five years of age would get a complete physical every three years, anyone twenty-six to thirty-five, every two years, and anyone over thirty-six, every year.[78] Military personnel not provided with a full physical would have a modified physical that could be done at a lesser cost of $50. The VECP results in Table 5 assume the military population is divided equally among the three age bands.

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[77] This example depicts only one element of a larger contract. Obviously, some people would need more extensive medical care as a function of their physical condition. Such care would be provided in a separate contract line item number (CLIN). Also, depending on a person's occupation, additional assessments may be required. This example focuses only on that element of the population required to have a physical as their annual health assessment.

[78] This example is not intended to imply that the military would ask for more service than it needs. Instead, it illustrates how risk/requirements trades can be made.

Table 5. Medical Service Contract Example After VECP Changes

CLIN	Description	Quantity	Unit	Unit Price	Total Price
0001	Provide a complete annual physical to military personnel	6,000	EA	$100	$600,000
0002	Provide a modified physical to military personnel	4,800	EA	$50	$240,000
	Subtotal	10,800			$840,000
	VECP Savings ($1,080,000 – $840,000)				$240,000
	Contractor's Share of Savings Using a 50/50 share ($540,000 × .5)				$120,000
0003	New CLIN for VECP savings	10,800	EA	$25.00	$120,000
	New Contract Total				$980,000

There are substantial benefits for the government—costs are reduced by more than 10 percent.[79] Without VE, however, there is no incentive for the contractor to propose such a requirements trade. To make it worthwhile in a service environment, a better mechanism of compensation may need to be found since a contractor needs some incentive to perform less work. When less work is performed, revenue is down, so there must be a balance or trade-off to increase profit to make such a VECP a worthwhile proposition for the contractor.[80] In this example, if we assume a 10 percent profit, the $120,000 share of the savings appears to more than compensate for lost revenue.

B. Complexities with Using Value Engineering in Service Contracts

While many types of service contracts offer savings opportunities, contracting officers dealing with such contracts often have little to no VE experience. In addition, these contracts present some inherent complexities in calculating how to actually share the savings. The problem with using VE in a service environment is that it is more difficult to:

- Identify the mechanisms for sharing savings, and
- Calculate savings with certainty.

1. Difficulties in Identifying Mechanisms for Sharing Savings

A chief mechanism for sharing VE savings in supply contracts is in the unit cost of production. In FAR 48.104-1, which describes how to determine the sharing period,

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79 A secondary issue is that indirect rates may have to be increased if there is a significant reduction in the number of billed hours.

80 There also are collateral savings associated with the VECP depicted in Table 6. Since the modified physicals take less time, people would not be away from work as long and therefore would be able to perform additional duties. Since this benefit is relatively small and difficult to quantify, such collateral savings are normally not claimed.

paragraphs (b), (c), and (d) make reference to units, low-rate initial production, early production, and production. For production-based VECPs, the government and the contractor know how many units are going to be purchased.

There is not always an intuitive analog to the unit cost of production in service contracts. Services may be priced for each performance effort on an hourly basis, priced for a total job that covers a short time period, or priced for a total job that covers a lengthy time period.

Table 6 assumes the Department of Defense enters into a contract to provide 500 person-months of 160 hours each over a three-year period for medical records data entry for $5.5 million. The contractor's cost per person-month is $10,000 and the price with profit is $11,000 per person-month.

Table 6. Data-Entry Service Contract Example Before VECP Changes

Quantity	Unit Cost	Profit	Original Unit Price	Total
500 Person Months	$10,000	$1,000	$11,000	$5,500,000

Through a VECP, the contractor proposes to purchase software for $1 million, which would increase efficiency and reduce costs by 40 percent, thereby reducing the number of personnel involved. The contractor would need only 300 person-months of 160 hours each over the three-year period. The savings would be calculated by reducing the quantity, but the original monthly cost and profit do not change. After deducting the new total and the cost of the software, the savings to be shared are $1.2 million. Split 50/50, each party receives $600,000. Therefore, under the VECP, the new unit price is calculated by adding in the contractor's share of the savings and dividing it by the number of person-months. This calculation is illustrated in Table 7.

Table 7. Data-Entry Service Contract Example After VECP Changes

New Quantity	Unit Cost	Profit	Per Unit Share of NRE	New Unit Price without Shared Savings	New Totals
300 Units	$10,000	$1,000[a]	$3,333[b]	$14,333[c]	$4,300,000
Total Savings (Original Price $5,500,000 – New Subtotal $4,300,000)					$1,200,000
Contractor Share of Savings using 50/50 share ($1,200,000 × .5)					$600,000
New Contract Total ($16,333 × 300 units)[c]					$4,900,000

[a] Profit is not reduced by the reduction in the cost base.

[b] $1,000,000 ÷ 300 units.

[c] The unit price with the VE savings is $16,333 since the new unit price of $14,333 would be increased by $2,000 ($600,000 savings ÷ 300 units).

The savings is achieved based on the quantity of hours being reduced. The unit price actually increases because of the addition of the shared savings and the fact that the hours are more productive (compared to the original contract) as a result of the investment in software.[81]

The concept of paying more for the services rendered after acceptance of a VECP may seem to be a questionable result. However, a fair means of compensation for the contractor must be achieved.

2. Difficulties in Calculating Savings

The application of the principles of shared savings is even more uncertain in a service environment when time-and-material (T&M), labor-hour (LH), and Indefinite-Quantity-Indefinite-Delivery (IDIQ) contracts are used. T&M and LH contracts carry a greater degree of uncertainty in the amount of effort being procured; therefore, estimating the amount of savings for a VECP becomes more difficult. These contracts impose greater risk to the contractor because orders may be insufficient to recoup investments and greater risk to the government because it may not get the benefit of the VE.

Under IDIQ contracts, the contractor is paid only for the effort it expends at a generally preset rate or rates. This type of contract has an estimated number of hours upon which the per-hour prices are based, but it is often a rough estimate that is frequently high. Consequently, if the contractor generates an idea that results in savings, it would be hard to calculate with certainty how much was actually saved.

This uncertainty makes calculating savings for a future contract more difficult. Consider the situation of a follow-on three-year contract for the medical service contract in Tables 4 and 5. The calculations would become more complex since, in the next three-year contract, those receiving a physical every two years would be examined twice. As personnel age and new recruits come in, the age ratio may change significantly from the simple example here. Similarly, in the data-entry contract example, uncertainties would arise about the quantity of data to be processed and about the new productivity after the purchase of the new software.[82]

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[81] If the period of performance was not three years, but a base year with two option years, the calculations becomes even more complex and less intuitive because all of the NRE would be charged to the base year. In this case, the unit price for the base year would be $23,000 and it would be $13,000 for the two option years.

[82] The FAR guidance in 48.104–1 on determining the sharing period makes it obvious that the drafters intended this section to be used in a production environment: "the sharing period begins with acceptance of the first *unit* incorporating the VECP" and "for engineering-development contracts and contracts containing *low-rate-initial-production or early production units*, the end of the sharing period is based…on the number of units affected by the VECP that are scheduled to be delivered over a period of between 36 and 60 consecutive months…that spans the *highest planned production*." [Emphasis added.]

3. Collateral Savings

For production or hardware contracts, the FAR requires that collateral savings be calculated as a one-time payment of 20 to 100 percent of a typical year of savings. One problem is calculating what a typical year of savings will be. Another issue may be negotiating the percentage share. On hardware contracts, collateral savings are usually a smaller part of what the savings from the change will be, so little attention is paid to them. The FAR clause even has an option where they can be waived if the cost to calculate them is determined to be too high; however, because of the unique circumstances surrounding service contracts, collateral savings may be significant. For example, in the medical services hypothetical, collateral savings could be calculated on the basis of military personnel being made available for additional work. In the data-entry example, collateral savings may result from fewer computer breakdowns. Both of these could be calculated but would be subject to uncertainty.

C. How To Make Service Contracts Work

The use of VE in service contracts is not prohibited by the FAR, but the current language is not conducive to its use in the service environment. Furthermore, VE savings are difficult to administer and calculate under current rules. Consequently, the government is missing opportunities for VECPs.

The difficulties associated with using VE in service contracts are not insurmountable. For example, there are alternative payment mechanisms to address the counter-intuitive situation in Table 7 where the labor rate increased to pay the VE incentives to the contractor:

- A separate contract line item number can be established to pay the contractor its share of the savings as the negotiated number of person-months is expended.
- The contract can be restructured to change the deliverables. Person-months can be converted into a mutually agreed upon quantity of output. In this case, the VE savings could be incorporated into the CLIN pricing for those results.
- Lump-sum-payment options could be agreed upon. In this case, the contractor and the government would agree on their relative shares of savings from future contracts (three to five years). The contractor would be paid its share upon initialization of the improved service.

None of these potential solutions is new. Each has been used before and there are both pros and cons to each approach. Individual circumstances would determine the most appropriate course of action.

Extending the duration of the third example identified the problem of calculating savings with certainty. This issue is much more complex than finding a mechanism to

share savings. For example, workload on a contract could be different than what is expected. If the workload were much less than expected, the contractor might not be fairly compensated for its investment if VE savings were paid on some per-unit basis. The opposite would be true if a lump-sum payment option were used. In this case, the government may pay more than its fair share to the contractor.

The problems would not be as difficult if the workload were greater than expected. When paying the shared savings on a per-unit basis, the contractor would have greater revenue than expected. However, the government would have more opportunities for savings. Therefore, both parties would benefit. Under a lump-sum option, all of the unanticipated benefit would go to the government. However, the contractor would have achieved its expected return on investment.

In addition, efficiencies gained from the contractor's investment could be different than anticipated. If shared savings were being paid to the contractor on a person-hour basis, and the efficiencies were greater than expected, then the government would benefit from the uncertainty because the contractor would have to provide more labor hours (and more output) to be paid. For a fixed amount of work, this becomes financially analogous to the situation above where the workload is less than anticipated. However, under a lump-sum approach, or in the case where payment is based on some measure of output, the contractor benefits because its cost per unit of output is lower. The government would attain only its expected savings.

If efficiencies were lower than expected and payments were made on a person-hour or lump-sum basis, the contractor would benefit and the government would lose. This happens because the government would be required to pay for the labor hours and associated incentives even though the expected output is less. If payments were made on the basis of a measured amount of output, both parties would suffer because total savings would be less than expected.

These situations would be complicated further if both workload and efficiency were different than the original estimates.

Triggers could be built into the revised contract to mitigate these situations. For example, the size of the VE incentive could be changed as a function of workload or efficiency, or the lump-sum payment could be made incrementally where the size of follow-on increments could be a function of workload or efficiency.

It is important to keep in mind that the FAR encourages contracting officers to be innovative. FAR 1.102-4(e) states:

> If a policy or procedure, or a particular strategy or practice, is in the best interest of the Government and is not specifically addressed in the FAR, nor prohibited by law (statute or case law), Executive order or other regulation, Government members of the Team should not assume it is

> prohibited. Rather, absence of direction should be interpreted as permitting the Team to innovate and use sound business judgment that is otherwise consistent with law and within the limits of their authority. Contracting officers should take the lead in encouraging business process innovations and ensuring that business decisions are sound.

Actions could be taken to support the use of VE in service contracts as long as they fall within the parameters of this FAR citation.

D. Concluding Comments

The government normally relies solely on competition before a contract is awarded to reduce cost on service contracts. After award, there is little incentive for the contractor to lower costs to the government without VE. If large scale use of VE in service contracts is viable, more experience is needed to deal with the situations described in this document. Ultimately, a body of knowledge must be developed from such experiences.

An important first step for determining viability in service contracts would be government use of the mandatory provisions of the VE clause to build a history of ideas and experience to guide longer-term changes. While the sharing ratio is smaller for the contractor under the mandatory program, it provides more incentive to pursue innovation because it mitigates the risks involved for funding the VECP activity in the voluntary program. Mandatory VE also puts the contractor in the best position to advise the government on ways to save and improve services. Under mandatory VE, the government would create a CLIN with defined areas to study. The contractor would be required to prepare a report/VECP on them or show that they are too difficult.

For the longer term, to effectively use VE for service contracts, a number of steps need to be taken. Guidance and training for VECPs in a service environment needs to be developed. The use of case studies and test cases could prove beneficial in expanding the use of VE for service contracts. These case studies could also be used to determine a quantifiable basis for determining the amount of funding to be applied to the mandatory VE CLIN. A primer in mandatory VE could be developed.

Finally, there may be a need to develop a FAR or Defense Federal Acquisition Regulation Supplement (DFARS) case to explore changes to the current regulations that will support the use of VE for services. A good way to approach this would be to publish an Advanced Notice of Proposed Rulemaking and ask government and industry to weigh in on how VE could be promoted in a service environment. One issue to be considered is whether a new contract clause is needed to increase the use of VE in service contracts. Examples of expanded coverage that may be appropriate could deal with options to revisit the deal, sharing non-recurring engineering costs, changing the savings share period, changing the share percentage, expanding the sharing period, and changing collateral savings to address these issues better.

10. Establishing a VE Program

A VE program cannot be established in a vacuum. It must be fully integrated with other organizational activities. Value engineering can be thought of as an enterprise change initiative. As early as 1984, Fraser wrote:

> The role of the value engineer/analyst involves managing change—from developing problem-solving skills of team members to increasing the acceptance of change proposals throughout the organization. [83]

James A. Rains, Jr. built on Fraser's theme. In the process of developing a FAST diagram for the value practitioner, he chose "encourages change" as the primary basic function and discussed how he perceived creativity to be a catalyst for change. [84] The lower level basic functions were as follows:

cause interaction → promote teamwork → form teams → develop topics/projects

As discussed in Chapter 6, moving left to right across the basic functions keeps answering the question, "How?" Change is encouraged by causing interaction. This interaction is accomplished by promoting teamwork as a result of forming teams. Finally, since teams are formed by people with the expertise required to work on a specific project, the topics or projects determine in part who to include. Moving from right to left along the same path explains why. Projects are developed in order to form teams to solve them. The teams are formed to promote the teamwork needed to cause the interactions necessary to encourage change.

To avoid conflict and competition with other enterprise-wide initiatives, Section A compares, and discusses the relationships between VE and a subset of enterprise change models or methodologies used in the Defense Department. Beyond these methodological, tool-based approaches to change, the Defense Department is also attempting to change its paradigm for affordability. Section B describes the link between VE and the Department's efficiency initiatives which are designed to improve value for the taxpayer

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83 R. A. Fraser, "The Value Manager as Change Agent: or 'How to be a Good Deviant,'" *SAVE International Annual Conference Proceedings*, Volume XIX, Sacramento, California, 6–9 May 1984, 199–203.

84 James A. Rains, Jr., "What is the Function of a Value Practitioner?—'Encourage Change'!" *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

and the warfighter. Section C concludes with a brief overview of best practices for establishing a VE capability in an organization.[85]

A. Integrating VE with Enterprise Change Model Initiatives

Several enterprise change models will be discussed in Subsection 1. Subsection 2 describes how VE interacts with them.

1. Enterprise Change Model Overviews

The following provides a short overview of Lean Six Sigma (composed of Lean, Six Sigma, and the Theory of Constraints) and Business Process Reengineering. To learn more about these models, a short bibliography of sources of further information is also provided.

a. Lean Six Sigma

Lean Six Sigma (LSS), as practiced in the Acquisition, Technology, and Logistics (AT&L) enterprise, is a combination of Lean, Six Sigma, and the Theory of Constraints (TOC). Each of these components has different origins.

(1) Lean

Lean concepts can be traced to the evolution of the Toyota production system in the decades following World War II.[86] They became established in the Western world in the 1980s and 1990s. "Lean thinking is the dynamic, knowledge-driven, and customer-focused process by which all people in a defined enterprise continuously eliminate waste with the goal of creating value."[87] Value creation is a central concept in lean thinking which seeks to build robust, adaptive, flexible and responsive enterprises. It uses a continuous-improvement process comprised of the following steps:

- *Visualize:* Visualize the desired future state and establish goals.
- *Commit:* Commit to change.
- *Prioritize:* Determine improvement priorities.
- *Characterize:* Define existing process/leverage points.

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85 Portions of this chapter were excerpted from Jay Mandelbaum, Heather W. Williams, and Anthony C. Hermes; *Value Engineering Synergies with Lean Six Sigma*, IDA Paper P-4586 (Alexandria, VA: Institute for Defense Analyses, September 2010).

86 Refer, for example, to James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine That Changed the World* (New York: Rawson Associates, 1990).

87 Earl M. Murman et al., *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative* (Houndmills, Basingstoke, Hampshire RG21 6XS, Great Britain: Palgrave, 2002), 90.

- *Improve:* Design and implement improvements.
- *Achieve:* Hold the gains and plan for future improvements.

See the following references for further information:

- Earl Murman, Thomas Allen, Kirkor Bozdogan, Joel Cutcher-Gershenfeld, Hugh McManus, et al., *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative*, Houndmills, Basingstoke, Hampshire RG21 6XS, Great Britain: Palgrave, 2002.
- James P. Womack, and Daniel T. Jones, "From Lean Production to the Lean Enterprise," *Harvard Business Review* (March-April 1994), 93–103.
- James P. Womack, and Daniel T. Jones, *Lean Thinking: Banish Waste and Create Wealth in your Corporation*, New York: Simon & Schuster, 1996.
- James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine that Changed the World*, New York: Rawson Associates, 1990.

(2) Six Sigma

Six Sigma has its genesis in the application of probability theory to statistical quality control. The goal of Motorola's Six Sigma initiative was to identify and reduce all sources of product variation—machines, materials, methods, measurement systems, the environment, and the people—in the process. The idea is not new. It can be traced to the introduction of lean thinking and Total Quality Management (TQM). At a technical level, Six Sigma's goal is to achieve virtually defect-free operations, where parts or components can be built to very exacting performance specifications. Underlying Six Sigma as a statistical concept is the construct of standard deviation, a measure of dispersions around the mean.[88] Reducing variation to the Six Sigma level denotes reaching a performance level of 99.99966 percent perfection (3.4 defects or non-conformance per million opportunities[89]). This level of performance means virtually defect-free production, where a defect is defined as any instance or event in which the product fails to meet a customer requirement.

Six Sigma can be characterized as a data-driven approach to continuous process improvement. It seeks to eliminate all sources of variation across the enterprise. The basic steps of a Six Sigma improvement process may be characterized as follows:

- *Define:* Define customer requirements and develop a map of the process to be improved.

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[88] Industry has a long history of using statistics. See, for example, Gerald J. Hahn, *The Role of Statistics in Business and Industry* (Hoboken, NJ: John Wiley and Sons, 2008).

[89] Defects per million opportunities indicates how many defects would be observed if an activity were repeated a million times.

- *Measure:* Identify key measures of effectiveness and efficiency and translate them into the concept of sigma.
- *Analyze:* Analyze the causes of the problem requiring improvement.
- *Improve:* Generate, select, and implement solutions.
- *Control:* Ensure that improvement is sustained over time.

See the following references for further information:

- Design for Six Sigma: The Revolutionary Strategy for Achieving Extraordinary Profits, Dearborn Trade, A Kaplan Professional Company, 2002.
- Forrest W. Breyfogle III, James M. Cupello, and Becki Meadows, *Managing Six Sigma: A Practical Guide to Understanding, Assessing and Implementing the Strategy that Yields Bottom-Line Success*, New York: John Wiley & Sons, Inc., a Wiley-Interscience Publication, 2001.
- George Eckes, *The Six Sigma Revolution: How General Electric and Others Turned Process into Profits*, New York: John Wiley & Sons, Inc., 2001.
- George Eckes, *Making Six Sigma Last*, New York: John Wiley & Sons, Inc., 2001.

(3) Theory of Constraints

The Theory of Constraints was developed by Eliyahu M. Goldratt, a physicist by education, in a series of publications over the past two decades.[90] According to Goldratt, TOC represents a paradigm shift to improve the concepts of Just-in-Time (JIT) and TQM to help stimulate the needed change. The important contribution of TOC has been its recognition at a conceptual level that systems should be viewed as "chains" of interdependence and that systems contain leverage points—constraints—where proactive change initiatives can deliver large positive effects on overall system performance.

TOC seeks to maximize throughput (the rate that the system generates money) by understanding and eliminating bottlenecks. Its overarching implementation framework may be characterized as follows:

- Establish the goal of the system, the units of measurement, and the operating measurements;
- Understand the system;
- Stabilize the system;

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[90] See for example Eliyahu M. Goldratt, *Theory of Constraints* (Croton-on-Hudson, NY: North River Press, Inc., 1990).

- Identify the constraint and carry out five focusing steps to decide how to overcome it;
- Implement buffer management;
- Reduce the variability of the constraint and the main processes;
- Create a suitable management structure;
- Eliminate the external constraint, sellexcess capacity; and
- Establish a continuous-learning program.

See the following references for further information:

- Eliyahu M. Goldratt, *Theory of Constraints*, Croton-on-Hudson, New York: North River Press, Inc., 1990.
- Eliyahu M. Goldratt, *The Haystack Syndrome*, Croton-on-Hudson, New York: North River Press, Inc., 1990.
- Eliyahu M. Goldratt, *What Is This Thing Called Theory of Constraints and How Should It Be Implemented?* North River Press, December 1999.
- Eliyahu M. Goldratt with Eli Schragenheim and Carol A. Ptak, *Necessary but Not Sufficient*, Great Barrington, Mass.: The North River Press, 2000.
- Domenico Lepore and Oded Cohen, *Deming and Goldratt: The Theory of Constraints and the System of Profound Knowledge*, Great Barrington, Mass.: The North River Press, 1999.

b. Business Process Reengineering

Business process reengineering (BPR) is the rethinking and redesign of business processes to achieve dramatic improvements in performance. One characterization of steps in the process is as follows:

- Determine the business vision and process objectives,
- Identify the processes to be redesigned,
- Understand and measure the existing processes,
- Develop alternatives for the process elements under consideration,
- Design and build a prototype of the new process,
- Evaluate the effects of the change, and
- Transform the business process across the enterprise.

See the following references for further information:

- Michael Hammer, "Reengineering Work: Don't Automate, Obliterate," *Harvard Business Review*, July-August 1990, 104–112.
- Michael Hammer, *Beyond Reengineering*, New York: Harper Business, a division of HarperCollins, 1996.
- Michael Hammer and James Champy, *Reengineering the Corporation: A Manifesto for Business Revolution*, New York: Harper Business, a Division of HarperCollins Publishers, 1993.
- T. H. Davenport and J. E. Short, "The New Industrial Engineering: Information Technology and Business Process Redesign," *Sloan Management Review*, Summer 1990, 11–27.

2. Relationships of Enterprise Change Models to VE

Several papers authored in the VE community have discussed one or more aspects of the relationship between VE and these enterprise change models. For example:

- In discussing how FAST (See Chapter 6, Section C.), coupled with creative techniques and supporting exercises, drives innovation, John E. Sloggy argues that

  > Innovation is what separates high-performing organizations from the rest of the pack. Value Management provides the vehicle to accelerate past the competition and reestablish dominance in business. It is the right tool for the times, and, utilized in conjunction with the Six-Sigma/Lean/TOC quality focus, it provides a viable solution to today's intensive competitive challenges. From a public sector standpoint, the same benefits of a creative approach to problem solving provide unique solutions that are cost effective in these times of dwindling resources and conflicting priorities.[91]

- Charles L. Cell and Boris Arratia discuss opportunities for using VE tools and techniques in the lean process. They argue that noteworthy benefits may be achieved by augmenting the VE job plan to specifically find and eliminate the seven wastes identified in lean thinking. William Thorsen shows parallels between the VE job plan and value stream mapping as used in lean thinking. Theresa Lehman and Paul Reiser describe the synergies between VE and the concept of lean in the context of the construction industry.[92]

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91 John E. Sloggy, "The Value Methodology: A Critical Short-Term Innovation Strategy That Drives Long-Term Performance," in *SAVE International 48th Annual Conference Proceedings* (Reno, NV, June 9–12, 2008), 6.

92 Charles L. Cell and Boris Arratia, "Lean Thinking and Value Engineering," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, 8–11 June 2003; William C. Thorsen, *Value Stream Mapping & VM*, SAVE International 45th Annual Conference Proceedings,

- Michael J. Cook points out that, although there are distinctions between VE and Six Sigma, there are strong synergies as well. He goes on to describe how the value methodology may be used to help Six Sigma practitioners successfully execute their projects and suggests that Six Sigma applications should become an area to market VE capabilities. In a subsequent paper, Cook suggests that organizations intentionally (1) adopt and practice both Six Sigma and VE as key strategies and (2) use them in a complementary manner to compound and enhance the advantages of each and thereby significantly enhance the benefits achieved. Cell points out that synergies between lean thinking and Six Sigma are increasingly being recognized. He goes on to say that when VE is integrated with them, individual strengths are amplified and weaknesses are overcome. He also suggests an integrated process.[93]
- Ball describes how the theory of constraints and VE work well together. He asserts that function analysis helps identify the constraints and the creative, evaluation, and development activities are similar to exploiting and subordinating the constraints.[94]
- Mary J. Rus has observed similarities between VE and Business Process Reengineering and proposes integrating the two methodologies. She suggests that the analytical elements of VE would be especially beneficial to Business Process Reengineering. Mir Farooq Ali and Saadi Assaf compare VE to Business Process Reengineering and Six Sigma on the basis of level of training, number of people involved, time to implement, and cost to implement.[95]

San Diego, California, 26–29 June 2005; Donald E. Parker, "Integrating Lean with Value Engineering," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005; and Theresa Lehman and Paul Reiser, "Maximizing Value & Minimizing Waste: Value Engineering & Lean Construction," *SAVE International 44th Annual Conference Proceedings*, Montreal, Quebec, 12–15 July 2004.

93 Michael J. Cook, "An Untapped Market: Energizing VM Usage Via the Six Sigma Methodology," *SAVE International Annual Conference Proceedings*, Volume XXXV, Reno, Nevada, 25–28 June 2000, 25–31; Michael J. Cook, "How to Get Six Sigma Companies to Use VM and Function Analysis," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, 8–11 June 2003; and Charles L. Cell, "VE, Lean and Six Sigma—Opportunities for Leverage," *SAVE International 44th Annual Conference Proceedings*, Montreal, Quebec, 12–15 July 2004.

94 Henry A Ball, "Value Methodology—The Link for Modern Management Improvement Tools," *SAVE International Annual Conference Proceedings*, Volume XXXVIII, Scottsdale, Arizona, June 8–11, 2003.

95 Mary J. Rus, "The Value Engineering in Business Process Reengineering—A Back to Basics Approach," *SAVE International Annual Conference Proceedings*, Volume XXXII, Seattle, Washington, 4–7 May 1997, 228–231; and Mir Farooq Ali and Saadi Assaf, "A Qualitative Comparison of Innovative Management Techniques in the Construction Industry," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

All these references are somewhat technical in nature. They have compared strengths, weaknesses, and attributes; examined the tools and processes; and developed ways to improve results by integrating with VE techniques. This document takes a broader perspective. Table 8 compares the four enterprise change models according to their goal, focus, scope, change process, and business model. See Kirk Bozdogan's "Comparative Review of Lean Thinking, Six Sigma and Related Enterprise Change Models," for a thorough discussion of the elements of this comparison. [96]

There are differences among the approaches. Table 8 shows that each has a different goal, focus, and business model. Some of the models have an enterprise-level scope, while others are narrower. All the models lead to incremental or continuous change. Differences beyond those in the table include the following:

- Each approach has its own identifiable evolutionary path,
- Some tools and characteristics are strongly tied to a single approach,
- Terminology is different, and
- Individual circumstances may lend themselves to one approach over another.

Despite the differences, all these models provide a positive impetus for performance improvement and change, enabling organizations to drastically improve their bottom lines.

[96] Kirk Bozdogan, "A Comparative Review of Lean Thinking, Six Sigma and Related Enterprise Change Models," Massachusetts Institute of Technology Working Paper, 3 December 2003.

Table 8. Comparison of Enterprise Change Models

	BPR	Lean	Six Sigma	TOC
Goal	Breakthrough solutions	Eliminate waste	Reduce business risk[97]	Eliminate bottlenecks
Focus	Business process	All enterprise processes and people	All sources of product/variation	Throughput
Scope	Business unit	Enterprise value stream	Enterprise	Enterprise
Change process	Radical	Evolutionary and systematic	Process specific, continuous	Continuous
Business model	Increase enterprise performance and customer value	Deliver value to all stakeholders	Minimize waste and increase customer satisfaction	Increase financial performance of core enterprise

Adapted from Lean Aerospace Initiative Lean Now Workshop, January 2003

Value engineering can be included in Table 8 as follows:

- *Goal:* Lower life-cycle cost and improve return on investment.
- *Focus:* Function analysis and function worth.
- *Scope:* Enterprise.
- *Change Process:* Incremental.
- *Business Model:* Increase value to the stakeholder.

The differences between VE and the other enterprise change models are not important in practice. Each approach uses its own process and these processes work. In fact, the boundaries merge in practice. While each approach may have strengths, rarely will a single approach be right for all aspects of a given situation. The complementary nature of the different approaches leads to synergistic benefits. DOD components are encouraged to integrate VE with other similar programs.[98]

B. VE and Efficiency Initiatives

In an effort to provide better value for the taxpayer and the warfighter, the Under Secretary of Defense for Acquisition, Technology, and Logistics signed a memorandum

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97 The original MIT entry for this cell was "reduce variation in processes." The latest thinking is that Six Sigma is primarily concerned with process improvement, but not all process improvement is focused on variation reduction.

98 DOD Inspector General Issue Resolution Agreement, "Defining Value Engineering (VE) for Reporting Purposes," 22 November 2000.

for acquisition professionals that provided specific guidance for improving the way DOD does business. That memorandum identified five broad areas of initiatives as follows:

- Target affordability and control cost growth;
- Incentivize productivity and innovation in industry;
- Promote real competition;
- Improve tradecraft in services acquisition; and
- Reduce non-productive processes and bureaucracy.

There are explicit VE contributions to the first four areas.

Mandating affordability as a requirement is one initiative under target affordability and control cost growth. This initiative requires a systems engineering tradeoff analysis showing how cost changes as the major design parameters and time to complete are varied. This analysis enables fact-based decisions about how the system could be made less expensive without loss of important capability. VE can be used to critically examine the value of every requirement and the specifications derived from it by comparing cost, function, and worth. This not only ensures that requirements are well founded, but also answers the question of whether the cost is comparable to the worth gained. In addition, it can identify ways to adjust the cost so the worth gained is more comparable.

Driving productivity growth through will cost/should cost management is a second initiative under target affordability and control cost growth. In this initiative, the Department is identifying unneeded cost and rewarding programs managers for its elimination over time. Program managers will be required and incentivized to develop should cost estimates that are below the budgeted (will) costs for those elements of their program where they believe they can be more efficient. VE can support this effort by incorporating available technologies, as well as the principles of economics and business management, into its procedures. When viewed as a management discipline, VE uses the total resources available to an organization to achieve broad management objectives. Thus, VE is a systematic and creative approach for attaining a return on investment by improving what the product or service does in relation to the money spent on it. Industry can be incentivized to participate as described below under “incentivize productivity and innovation in industry.”

Eliminating redundancy within warfighter portfolios is a third initiative under target affordability and control cost growth. For this initiative, the Department is trying to make value-based, portfolio-wide decisions that could not be supported by data from a single program in isolation. Function analysis, a distinguishing feature of VE, is a very powerful tool to aid in such decisions. The term function describes everything that makes a product (or process) work, without specifying the means. Function analysis leads to the performance of only the *necessary* functions at minimum overall cost. Redundancy

would be easily identified if it does not add value to the customer commensurate with its cost.

Removing obstacles to competition is an initiative under promote real competition. Under certain circumstances, VECPs have been used to promote competition. One circumstance was a sole source provider of an expensive component, where the prime contractor was aware of other companies wishing to compete. The second circumstance was a situation where the prime contractor simply felt that a sole source component was too costly. In an effort to reduce cost and increase competition, VECPs were used to develop alternative sources with support from the prime contractor and the government.

An initiative to reward contractors for successful supply chain and indirect expense management is part of incentivize productivity and innovation in industry. VECPs provide businesses with a strong profit-based incentive for using its skilled engineering workforce to mitigate DOD's cost issues because the contractor receives a substantial share in the savings accrued as a result of implementation. VECPs therefore provide a vehicle through which acquisition and operating costs can be reduced while the contractor's rate of return is increased. This applies to prime contractors as well as their supply chain and it is not limited to indirect expense management. VECPs are applicable beyond cost plus and fixed price contracts. Incentive contracts with share lines provide a negotiated way to share under runs and overruns on incentive contracts. While any VECP savings generated for the current contract will be captured under the share line, VECPs must be used to share the savings on concurrent and future contracts as well as sharing in any collateral savings.

Addressing causes of poor tradecraft in services acquisition is part of improving tradecraft in services acquisitions. The Federal Government now predominantly spends its contract dollars on services – these contracts represent a vast untapped source for the application of VE. VECPs can be applicable to service contracts. If the unit price can be changed to reflect the VECP, then a service contract would operate much the same as a hardware contract and similar benefits to both the government and the contractor would accrue. Performance based (service) contracts do not obviate the need for VE. VE can change the business case by providing the proper incentives for the contractor to adopt an approach more beneficial to the government in the long term. For example, when Technical Data Package changes do not pay for themselves (or pay back enough) under the current contract, VECPs are still needed because they lock in savings on future contracts. Even a negotiated sole source contract with option years does not lock in the savings for the contractor; the government may require certified cost and pricing data before exercising an option. Finally, VE is also more likely to find solutions with other collateral benefits because its methodology is designed to identify a broad range of potential solutions that have impact beyond the immediate problem at hand.

C. Best Practices for Establishing a VE Capability in an Organization[99]

P.L. 104-106 requires each executive agency in the Federal Government to establish and maintain cost-effective VE procedures and processes. The most effective way to comply with this law is through top-management support, institutionalized in written policy that is adequately resourced. The discipline and rigor involved in applying the value methodology usually cannot be sustained in a bottom-up approach. Leadership attention will ensure implementation and continuing support from the entire organization. Setting goals and objectives that can be tracked through metrics provides a rationale for change and an impetus to succeed.

A designated VE leader with open communication channels to top management is also important. That person should have established credibility as a problem solver and possess people and management skills. Knowledge of the VE methodology can be developed over time and capable facilitators can be made available. The leader must:

- Understand the viewpoints of potential customers to convince them that VE can help them achieve their goals. Although some problems may be brought to a VE team, in the beginning, the team must be able to market its capabilities to others in the organization. There are advantages to choosing the problem to attack, since problems brought to the team's attention may be difficult to solve.
- Promote the use of VE techniques by government personnel.
- Develop orientation training that acquaints others with VE policies, procedures, and benefits.
- Choose projects with a high probability of a favorable outcome (as discussed in Section A). Early failures can be extremely detrimental to a VE program; success builds on success.
- Encourage contractors to respond to the VE clauses in DOD contracts and thereby share the resulting cost savings.
- Focus first on achieving measurable results and second on other intangible benefits. Although there usually are intangible benefits to a VE project, quantifying them can be difficult. Typically, such intangibles are conveyed through anecdotes that may not be convincing to decision-makers evaluating the success of a VE program. It is also important not to promise too much. If

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99 The material in this section draws upon James A. Rains, Jr., "Creating and Maintaining an Effective and Successful Value Analysis Program," *SAVE International 45th Annual Conference Proceedings*, San Diego, California, 26–29 June 2005.

people's expectations are not met, a successful outcome may not be viewed as such.

- Ensure that management is heavily involved in the Orientation and Implementation Phases of the job plan. The Orientation Phase initially sets the scope and objectives for the projects. These must be aligned with management needs. Making a decision to change does not imply that the expected benefits will be realized. Implementation of the decision is often a long, arduous process. Management must be kept informed to help overcome roadblocks and to avoid surprises.
- Ensure adequate preparation for workshops, including use of proper data sources and a complete plan. Skill in applying the VE methodology does not ensure success. Contingencies must be planned for in advance. If, for example, at the last minute, a key person becomes unable to participate, reschedule the workshop to accommodate the conflict.
- Ensure that the VE methodology is applied carefully and thoroughly (as discussed in Chapter 6).
- Publicize VE results to the entire organization. As accomplishments become well known, more opportunities will be presented. Recognize successful accomplishments and fully credit the team and the people that developed and implemented the change.
- Provide VE practitioners with ample training to continuously improve their skills (as described in Chapter 11).
- Utilize experienced professional VE consultants to supplement in-house staff as needed. A consultant directory is available on the SAVE International Web site, http://www.value-eng.org/professionals.php.
- Nominate recipients for the DOD VE Achievement Awards.

While all of the above apply to construction, the following defines, in general terms, additional organizational duties and responsibilities to consider in managing VE activities.

The Central Office:

- Establishes a specific VE program appropriate to the mission and organization;
- Emphasizes through training, evaluation and other programs the potential for VE to reduce unnecessary costs;
- Establishes criteria and guidelines to identify projects most appropriate for VE;

- Ensures that responsible officials document why projects were not selected for VE;
- Establishes guidelines to evaluate and process VE proposals; and
- Develops and issues regional guidelines for administration of the VE program, collect data on regional VE activity and forwards reports to the DOD VE Program Manager.

Assistant Regional Administrators

- Ensure that regional offices operate in accordance with applicable requirements and VE program guidance issued by the Agency Program Manager;
- Ensure regional compliance with reporting requirements; and
- Name a single point of contact in the region for all matters pertaining to the VE program.

D. Concluding Comments

As part of the Defense Department's attempts to reduce the total ownership cost of its weapon systems and infrastructure, application of programs such as Lean, Six Sigma, Theory of Constraints, and Business Process Reengineering does not preclude an active, formal VE effort. VE tools have been proven to help implement these other programs.

Business process improvement initiatives are cyclical in nature. They evolve over time and can ultimately be replaced by processes that attempt to integrate specific attributes of older initiatives with the latest approaches and/or technologically enabled methodologies. Practitioners often differentiate their initiatives from others because of different origins, vocabulary, skills, and training; effectiveness in particular circumstances; and applicability to a specific problem. Unfortunately, these differentiations are not always important, and can create organizational stovepipes that compete with one another. A successfully implemented methodology may not be the best and only one for every problem. Depending on the situation, integrating multiple approaches can provide valuable ideas and insights that augment the benefits of using the approaches separately. Such synergies not only achieve better results, but also break down the organizational stovepipes that naturally occur when different offices are assigned responsibility for different problem-solving methods.

11. VE Education and Training

There are many possible sources of VE education and training. Within the Department of Defense, the Defense Acquisition University offers an online continuous-learning VE overview module.[100] Section A of this chapter summarizes the Defense Acquisition University's course offerings.

Some colleges and universities teach the methodology in greater detail. One of the missions of the Lawrence D. Miles Value Foundation is to create and promote teaching value methodology courses at the university level. Currently, the Foundation has established agreements with several universities to offer certain VE courses.[101]

SAVE International offers its members education and training, publications, tools for promoting the value methodology, certification, networking opportunities, and recognition. SAVE also maintains a directory of "value consultants" who can lead studies or train others in VE techniques and who sponsor courses covering the value methodology and related disciplines. Section B describes SAVE International's professional certification program.

Private companies also provide VE training for their own employees and their customers. Nearly all colleges and universities teach disciplines related to the practice of VE. Section C presents some ideas about these other sources of VE education and training.

A. Defense Acquisition University

The Defense Acquisition University offers a continuous-learning online course on value engineering.[102] This course provides an overview of value engineering for multidisciplinary government, military, and civilian personnel, including program managers, systems engineers, acquisition and logistics personnel, functional leaders, and contractors. It is divided into six chapters with learning objectives as follows:

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[100] Search for value engineering at https://learn.dau.mil/html/clc/Clc.jsp?fTopic=All&fKeywords=Value+Engineering&Submit=Search.

[101] See the Lawrence D. Miles Value Foundation Web site at http://www.valuefoundation.org/education.htm.

[102] A course description for the course, CLE001 Value Engineering, is available online at https://learn.dau.mil/html/clc/Clc.jsp?fTopic=All&fKeywords=Value+Engineering&Submit=Search. The course learning objectives are taken from this Web site.

- Chapter 1: Introduction to Value Engineering
  - Define Value Engineering
  - Understand the benefits of using Value Engineering for the government
  - Understand the benefits of using Value Engineering for the contractor
- Chapter 2: Applications of Value Engineering
  - Understand where and when Value Engineering can be applied
  - Understand VE misconceptions
  - Describe some VE successes in the Department of Defense
- Chapter 3: Implementation through VE Workshops
  - Understand the benefits of conducting VE workshops
  - Describe how to prepare a workshop
  - Understand the outcomes of a VE workshop
- Chapter 4: Understanding the VE Methodology
  - Describe the phases of VE methodology
- Chapter 5: Using Value Engineering Change Proposals
  - Describe the various types of VE contract clauses
  - List the steps for VECP approval by the government
  - Explain the different types of VE settlements and their application
  - Describe some techniques which will increase the contractor's probability of success for government approval of the VECP
- Chapter 6: Summary of Value Engineering

B. Professional Certification[103]

Individuals may obtain certification in the practice of the Value Methodology through SAVE International. The three levels of certification are available:

- The Associate Value Specialist is at the entry level. Requirements include training in the basics and some limited experience.
- The Value Management Practitioner is at the mid-level. Additional requirements beyond an Associate Value Specialist are experiential. This certification level

[103] The material in this section has been extracted from the SAVE International Web site, http://www.value-eng.org/education_certificationprg.php.

recognizes those individuals who have acquired the basic skills of value engineering/analysis but their principal career is not value engineering.

- The Certified Value Specialist is the highest level of certification for people whose principle career is value engineering. Advanced training and leadership and managerial experience beyond the Value Management Practitioner are required.

The following are among the certification program's objectives:

- To create and maintain professional standards and improve the practice of the Value Methodology by identifying courses that meet the required education and training criteria.
- To establish and maintain a professional recognition program encouraging practitioners in the Value Methodology field to improve professional education and training skills and competence in accordance with the standards.
- To clarify methods and procedures in the application of the Value Methodology; to create a better understanding of the value profession; and to develop universal acceptance and increased application of value practices.
- To establish and maintain ethical standards for workshops and seminars.
- To encourage the development and application of the Value Methodology and provide examples of successful application of projects in industry and government.

Topics covered in SAVE International's basic and advanced training courses are as follows:

- Basic Training
  - History, definition, job plan
  - Function, FAST, function-cost
  - Creativity
  - People topics
  - Cost
  - Basis of cost analysis
  - Evaluation and implementation
- Advanced Training:
  - Project and team structure
  - Job plans

- Function analysis and FAST diagramming
- Creativity process
- Financial evaluation
- Interpersonal skills
- VM interactions within organizations

SAVE also conducts other training seminars. Topics have included creativity, facilitation skills, FAST, life-cycle costing, and Quality Function Deployment.

Another certification program for VE, the "Value Engineering Leader Certification Program," is registered with the All-Japan Foundation of Management Organizations conducted by the Society of Japanese Value Engineers.

C. Other Sources of VE Education and Training

Certification should not be the end or the only avenue of VE training; other sources are available to provide both basic and advanced VE skills. Selecting the most appropriate subjects and the right learning method depends on the organizational and individual preferences. The following provides some ideas along these lines:

- SAVE International's main educational and training opportunity comes at its annual conference. Conference attendees can hone and refine their skills, exchange ideas with peers, listen to presentations illustrating the latest thinking about VE applications, and interact with exhibitors who provide VE products and services.
- A Value Methodology course administered by Value Management Strategies is available through the Miles Value Foundation Website.[104] The course consists of fifteen narrated, animated lessons (with quizzes and interactive exercises) of up to two hours each. At the conclusion of the course, participants should be able to:
  - Describe VE history, uses, benefits, and characteristics.
  - Explain the concepts of value, cost, performance, time and risk; identify how these concepts affect projects; and apply techniques to define and improve the value of a project.
  - Use VE's technical tools and techniques for each phase of the job plan including function analysis and FAST diagramming, communications and facilitation techniques for multi-disciplinary teams, creativity and evaluation

[104] http://www.valuefoundation.org/course.htm.

techniques, alternative development and analysis, and presentation techniques.Other VE training programs are available on the Web.

- Joseph F. Otero, Jr., Timothy T. Beadle, and Christine A. Magaldi describe Pratt & Whitney's internally developed formal training and certification process.[105] This comprehensive program has expanded the use and reputation of the value methodology in the company. The authors list learning objectives for value management practitioner training in the article's appendix.
- Hannan makes the case for expanding and enhancing VE professional skills using role-specific training programs.[106] He provides several examples (project selection and team building, facilitation tools and techniques, and creative problem-solving strategies) designed to meet the needs of some of his clients. Hannan's concept of role-specific training is not limited to the VE practitioner. He also suggests supporting programs such as value methodology awareness seminars and training for value management team members.
- Carlos Fallon describes the body of knowledge underlying the value discipline from a university perspective.[107] He lists the college subjects that provide the basic knowledge behind the VE job plan, as well as useful technical electives at the undergraduate level. Fallon also suggests potential course (and other) requirements for a Master of Science degree in value analysis.
- Cook describes the skills and competencies required to be an outstanding VE consultant.[108] He classifies them in categories of basic traits, supporting skills, interpersonal skills, and technical skills. While explicitly linked to consultants, Cook's work is equally applicable to any VE practitioner. Table 9 lists the subjects that Cook includes under each of the four headings.

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105 Joseph F. Otero Jr., Timothy T. Beadle, and Christine A. Magaldi, "Accelerating the Development of Value Management Practitioners," *SAVE International Annual Conference Proceedings*, Volume XXXVI, Fort Lauderdale, Florida, 6–9 May 2001.

106 Donald Hannan, "A Re-evaluation of our Profession: Customized Role Specific Training Programs & Client Specific VE Workshops," *SAVE International Annual Conference Proceedings*, Volume XXXVII, Denver, Colorado, 5–8 May 2002.

107 Carlos Fallon, "Body of Knowledge Underlying the Value Disciplines," *SAVE International Annual Conference Proceedings*, Volume XXX, Miami, Florida, 24–26 May, 1971, 19–26. Republished in Value World, Volume 27, Volume 2, Fall 2004, 17–22.

108 Michael J. Cook, "Essential VE Consulting Skills," *SAVE International Annual Conference Proceedings*, Volume XXXIV, San Antonio, Texas, 27–30 June 1999, 52–60.

Table 9. Essential VE Consulting Skills

Category	Skill
Baseline	Trustworthiness
	Character
	Authenticity
Supporting	Administrative skills
	Negotiation skills
	Commitment-building skills
	Meeting management
	Expectation management
Technical	Function analysis
	Report-writing and documentation
	FAST diagramming
	Storyboarding
	Analytic skills
	Evaluation techniques
	Problem identification and definition
	Scientific methods
	Decision-making tools
	Scribing techniques
	Creativity techniques
	Financial skills
	Application area knowledge
Interpersonal	Building relationships
	Perception
	Valuing diversity
	Communication skills
	Dealing with resistance
	Resolving Conflict

Source: Michael J. Cook; *Essential VE Consulting Skills*; SAVE International Annual Conference Proceedings; Volume XXXIV; San Antonio, Texas; 27–30 June 1999; 52–60.

- As discussed earlier in this document, VECPs provide opportunities for government procurement agencies, prime contractors and supply chain organizations to create win-win-win situations. The government is able to acquire supplies and services at less net cost. Prime contractors and supply chain participants enhance their position as good value providers and earn additional profit. Training (both four hour and eight hour versions) on this subject has been provided at DMSMS and SAVE conferences and may be obtainable from the Systems Engineering Office in the Office of the Secretary of Defense for

specific organizations. This training uses interactive case studies to introduce participants to the regulatory requirements and the process of preparing, submitting and settling VECPs. Various contract- type VECPs are reviewed.

D. Concluding Comments

Many sources of basic and advanced VE training are available to the government and industry. SAVE International is an excellent source for keeping abreast of the latest research in VE, particularly concerning human interaction and overcoming resistance to change. Attending the annual SAVE conferences is one of the best ways to learn the most up-to-date information. (SAVE Conference Proceedings were the source of much supporting information in this paper.)

12. Promoting VE in Government and Industry

A. Background

Assistant Secretary of Defense (Research and Engineering) Zachary Lemnios explained the importance of VE to national security:

> Across the Department's Research and Engineering enterprise, we are driving Innovation, Speed, and Agility. These coordinates can be applied to the Value Engineering community. They define the approach and operating space in which you work and for which so many are today receiving awards. Innovation, Speed and Agility are critical to transforming how the Department examines processes, provides solutions and fields capabilities to our Warfighters.
>
> Congress and our Secretary have placed an emphasis on a critical examination of, and increased efficiency in, how the Department spends the American tax-payer dollars. Last Saturday, the Secretary of Defense emphasized this priority when he stated that, "The goal is to cut our overhead costs and to transfer those savings to force structure and modernization within the programmed budget." This is no easy task and it falls to you, the Value Engineering community to lead the way and to the Department to accept this challenge and provide continuous process improvement as part of the solution. The way forward is embedded in the Value Engineering mandate: to identify actions that reduce cost, increase quality, and improve mission capabilities. [109]

Despite such endorsements and despite VE's proven track record of generating more than $1 billion annually in cost avoidance and savings (see Figure 2 in Chapter 1), there is a great deal of unrealized potential, especially for VECPs and for VE in service contracts (see Chapter 9). A 1997 VE Process Action Team report identified a number of barriers to the increased use of VECPs.[110] Since that time, many of these barriers have been mitigated as discussed below.

From the viewpoint of a Program Manager:

- Although programs are not entitled to the savings generated from cost-reduction initiatives, in some cases, they have been allowed to keep them.

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[109] Remarks by the Honorable Zachary Lemnios, Assistant Secretary of Defense (Research and Engineering), Value Engineering Awards Ceremony, 12 May 2010.

[110] "Final Report of the Process Action Team on Value Engineering Change Proposals," Office of the Under Secretary of Defense for Acquisition and Technology, May 1997.

- *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046, Mandelbaum and Reed, October 2006, shows untapped potential for flexibility and tailoring allowed by the FAR to accommodate the needs of the government and its contractors.
- As a result of the Office of the Secretary of Defense's efficiency initiatives (see Chapter 10), VE is receiving increased attention from a policy perspective.

From the viewpoint of a contractor:

- The FAR was modified to give the PCO the flexibility to increase the contractor savings share from 50 percent to 75 percent, to extend the sharing period from three to five years, and to raise the contractor collateral savings share from 20 to 100 percent of an average year's savings.
- The previously referenced *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts* and the update of the *Contractor's Guide to Value Engineering* associated with this document[111] provide a great deal of helpful information.

Additional effort is ongoing in two areas—greater leadership attention and improved VE know-how. Increasing VE expertise by itself is not enough. Similarly, management emphasis, without the know-how, will not be especially effective. Chapter 10 provided some best practices for establishing a VE program, a key element of which involved top management support.[112] The remainder of this chapter deals with building VE know-how in both the Defense Department and industry.

B. Building and Using a VE Community of Practice

One of the most effective ways of improving expertise in a subject is to link knowledge seekers with knowledge sources (both written and experiential). Communities of practice (CoPs) are proven vehicles for making these connections, for linking people with experience to others who can benefit from their insight and knowledge.

A CoP is a group of individuals with similar interests that works together to facilitate communication, share knowledge, and solve common problems. CoPs cross organizational lines and geographical boundaries. By nurturing a trust-based culture, CoPs foster interaction among people at different levels and with varying subject matter expertise; they enable group members to develop professional relationships with leaders

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111 See Chapter 7.

112 Additional and continuous high-level emphasis by senior Office of the Secretary of Defense leadership both within the Defense Department and to industry will also help significantly. Further discussion of this topic is outside the scope of this document.

in the field. By providing a safe environment to share challenges, exchange best practices, and test new ideas, CoPs stimulate collaboration and innovation.

Such an approach is being applied to VE. The CoP initially focused on VECPs has been organized to help practitioners share and learn from one another. The CoP can be accessed by going to the Defense Acquisition University's Acquisition Community Connection Web site, https://acc.dau.mil/CommunityBrowser.aspx?id=399567&lang=en-US. The CoP will help participants navigate the VECP process, improve the probability of successful VECP evaluations, provide assistance and answers to technical questions, and serve as a forum for disseminating the latest information. Contracting officers, VE practitioners, program offices, and industry are all encouraged to use this CoP to share and build on the material in this document.

Figure 15 captures the opening page of the Defense Acquisition University Community Connection Web site. It shows the four major elements of the VECP process—idea generation, selling the VECP, VECP approval, and VECP settlement. The additional information provided on each of these four topics is reproduced in Subsections 1 through 4, respectively. Each of these subsections describes its corresponding portion of an overall flowchart (shown in Figures 16-19) of the VECP process. Yellow blocks signify contractor activities for which further information is provided; blue blocks signify government activity for which further information is provided. The widespread dissemination and use of this information, along with sharing other knowledge and experience, will help advance VE strategic objectives and provide increased profit and other benefits to the contractor; the Defense Department will benefit from cost savings and improved system performance.

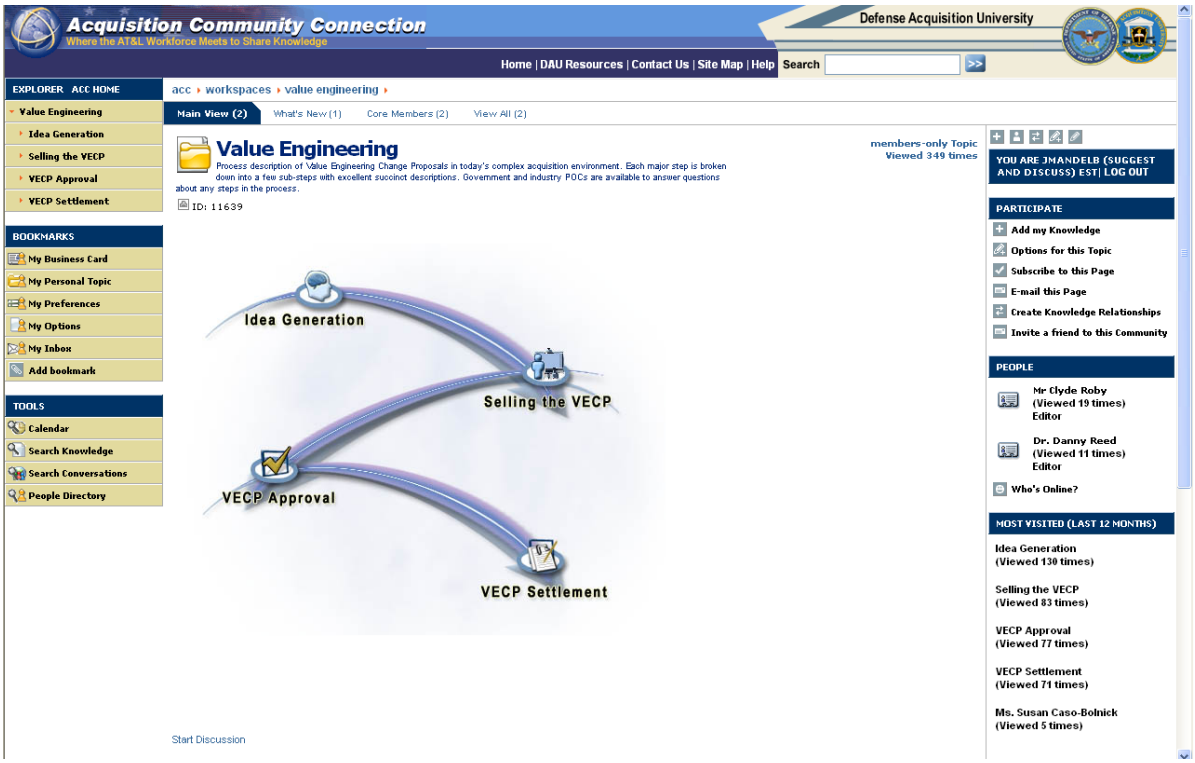

Figure 15. Entering the VE Community of Practice

1. Idea Generation

Figure 16 portrays the idea-generation process.

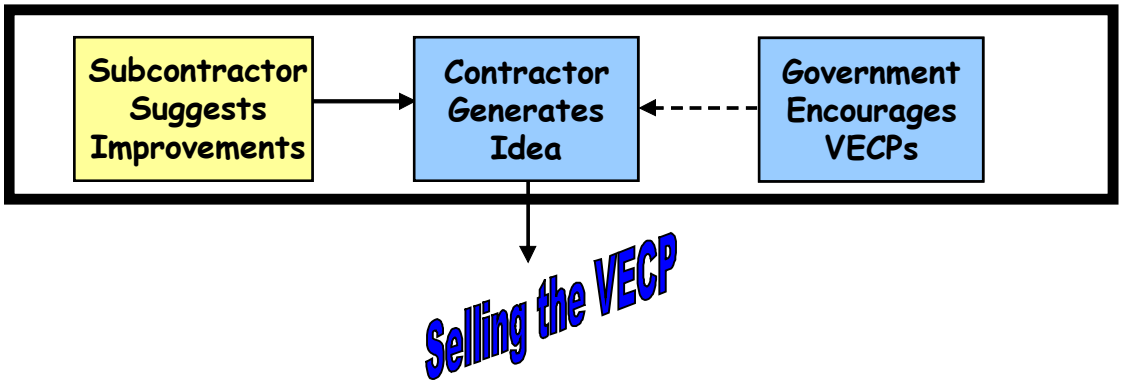

Figure 16. VECP Idea Generation

a. Contractor Generates Idea

The following are several best practices for a viable contractor VE program:

- The company should establish VECP goals
- VECP goals should flow down through the corporate structure.
- Contractor management personnel should be involved in VECP decisions and approve VE operating goals and budgets.
- Contractor management personnel should consult with key government personnel on the use of VECPs as a cost-reduction tool and gain government agreement on the need to apply the VE methodology to the system being acquired.
- Contractor personnel should benefit from contributions to approved VECPs in the form of special awards and/or recognition.
- Contract negotiators should understand the FAR VE provisions.
- VE sharing provisions should be in subcontracts as company policy.
- The company's accounting department should identify VECP income separately so that:
  - Management personnel can recognize the monetary benefit of VE.
  - Management can be kept informed of expenditures and receipts resulting from the VE effort.
- Resources should be assigned specifically for developing VECPs.
- The company should work to minimize the time to:
  - Develop a VECP.
  - Obtain internal approval before submitting a VECP to the government.
- The company should conduct formal VE workshops to expand in-house capabilities.
- There should be a strong VE training and indoctrination program.
- There should be close coordination between government contract administration and the company's marketing efforts with respect to VECPs.

b. Subcontractor Suggests Improvements

While only the prime contractor can submit a VECP, many potential ideas can be developed by a subcontractor.

- Prime contractors and their subcontractors have a unique contractual relationship; the government customer has no involvement.
- The government customer deals only with the prime contractor.
- The entire supply chain can benefit from reducing system cost, increasing performance, and accelerating fielding.
  - It makes the prime contractor more competitive.
  - It strengthens the business relationship between the prime contractor and its subcontractors.
  - Savings can be shared.
- The prime contractor should encourage its subcontractors and their suppliers to participate in VECPs.
  - Prime contractors should have a business plan for encouraging subcontractor involvement in VE process. This plan may be developed jointly with the government customer.
  - Incentives may be offered.
  - It could be a way in which suppliers are evaluated.
  - Prime contractors often develop “roadshow briefs” on VECPs for subcontractors or convene periodic meetings to address/resolve prime contractor-subcontractor issues. These meetings are opportunities to address VECP opportunities and rewards with subcontractors. A joint government/prime contractor/subcontractor VE workshop is an excellent way to substantiate the benefits to all parties.
- The subcontractor should propose a business plan to the prime contractor to maximize VECP benefits for all parties—prime contractor, subcontractor, and government customer. The proposed change could affect other contracts the prime contractor has with the subcontractor or other business the subcontractor may have with other companies. If there is a large investment required, a way may be found to minimize the nonrecurring expenses to the instant contract by spreading these costs over multiple programs. The prime contractor may be willing to pay large nonrecurring expenses that cannot be offset on the current contract for some consideration or may offer greater returns if the subcontractor provides the funding. Other business that they conduct with each other could affect their willingness to initiate the VE effort and might be considered.
- The way savings are split is entirely dependent on the negotiations between the prime contractor and the subcontractor. The FAR VE clause (FAR 52.248-1(l)) requires the prime to insert “an appropriate VE clause” in all subcontracts of

$100,000 or more and may include one in those of lesser value. “Appropriate” should be interpreted as being a clause that sufficiently motivates a subcontractor to prepare and submit VECPs to the prime for further submission to the Federal Government.

  - The Federal Government recognizes the importance of VECPs developed by subcontractors (where 75 to 85 percent of the actual work takes place) by allowing (per FAR 52.248-1(l)) the subcontractor to “take the first bite out of the apple” on instant contract savings—even if that means no instant contract savings are left for the prime contractor and the government to share. However, there must be overall savings for the government, and the government must be the primary beneficiary of all concurrent, future, and collateral savings.

c. Government Encourages VECPs

At a general level, VE advocates should brief program offices about the importance and benefits of VE.

- At every opportunity industry should be told of the government’s interest and receptiveness to VE.
- The Program Manager should use meetings with contractors to express interest in VECPs throughout the acquisition process.
- VE advocates should explain the need for VE to Defense Contract Management Agency representatives, who in turn could present a VE briefing to contractors and try to promote VECP champions in industry.
- The program office should encourage the contractor to think about additional ideas and recommend other areas where the government would be receptive to VECPs.

2. Selling the VECP

Figure 17 depicts the process of selling the VECP.

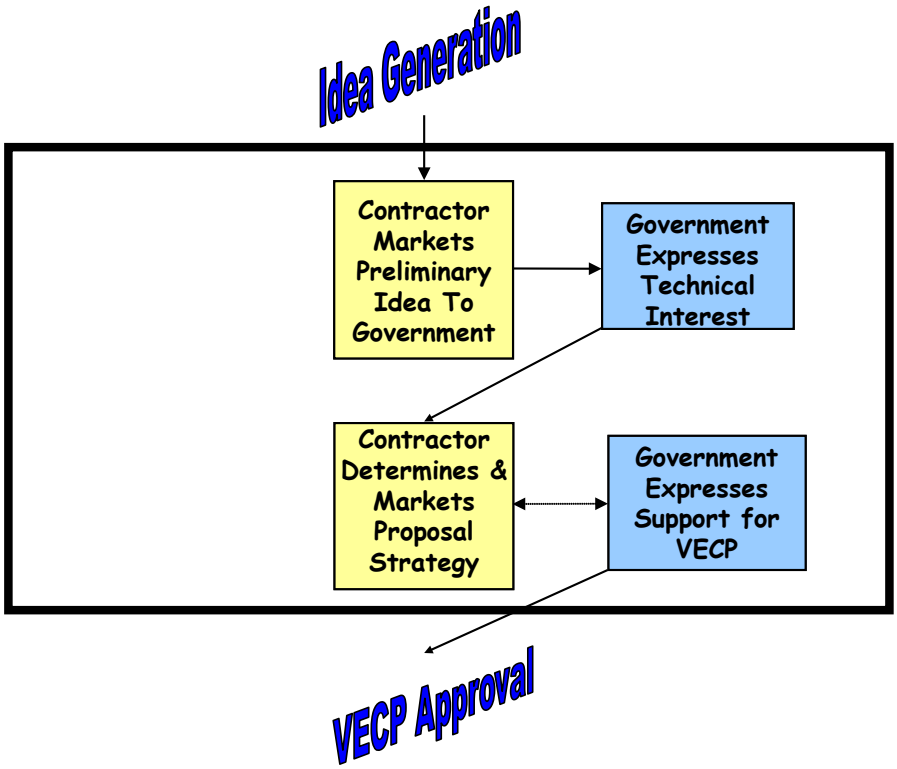

Figure 17. Selling the VECP

a. Contractor Markets Preliminary Idea to Government

This is a low-key activity designed to gauge whether there is any government interest—it does not, however, generate a commitment by the government.

- The contractor should brief the idea to the government technical team or equivalent thereof.
  - There should be limited contractor investment in the briefing.
  - It is a good idea to include a rough-order-of-magnitude pricing and potential savings.
  - The contractor should also indicate potential risks in cost, schedule, and performance.
  - It is important to address when the VECP effort would be completed (i.e., when the new configuration is tested and qualified). The government can make a VECP uneconomical by expending all the savings on expensive

testing. This is more likely to happen with missiles and aircraft because of safety, but it is always a concern. That is why "qualification" is included even in some preliminary briefings. The contractor wants the government to agree that its approach seems correct. For example, the contractor might suggest that if a flight test is required, it be a "ride along" as part of another flight test so there is virtually no cost.

- It is generally advantageous from a customer acceptance perspective to also include a short synopsis or information paper.
- Contractors should also seek feedback on government needs.
  - Should the idea be modified?
  - Would the government be receptive to VECPs in other areas?
- Desired outcome: a statement of government interest and technical feasibility.
  - The government should tell the contractor exactly what additional technical information should be provided when making a more formal presentation.

b. Government Expresses Technical Interest

View the contractor's suggestion as an opportunity for the government to save money and improve performance.

- Ensure the right people are present.
- Be constructive; make suggestions for how the ideas can be improved.
- Provide the contractor with an honest and complete assessment of what is presented as well as additional technical information needed.

c. Contractor Determines and Markets Proposal Strategy

Below are some of the key questions the contractor considers before formally presenting the idea to the government:

- How the VECP should be proposed: either as a "voluntary" effort on its part (maximum risk but maximum savings) or as a "mandatory" clause incorporated in the contract (risk reduced due to government sharing the risk and government funding all or part of the development and implementation costs; because of the reduced risk, there is reduced sharing benefit to the contractor).
- Who (contractor or government) should invest what and when for maximum savings and return.
- How big or small the VECP (assuming it is not a simple one-item change) should be. When dealing with long, stable production runs, it may be desirable

to break the proposed change into two or more VECPs to ease processing or approval, or it may be helpful to lump several smaller changes into one big change. Combining ideas may be for marketing purposes. Often the government wants to change something, but cannot afford to do so. The contractor might incorporate the government's desired change into the VECP (even though the government-desired change saves little or nothing). By letting the government-desired change become a part of the VECP, the contractor can make the VECP more marketable. The same would hold true for some things the contractor wants to change that would not be economically viable unless part of a larger VECP.

- Which contract could/should be the instant contract. Among the many factors to consider are which contract will have the most impact, re-bid considerations, and so on.
- What the implementation schedule, including savings period/share (three to five years), should be.
- When the activity should be started. The contractor should explain how it might be accomplished as soon as possible.

The contractor should prepare a formal presentation to the government justifying the VECP.

- On simple VECPs, a formal presentation may not be required, just a courtesy phone call to the recipient with the offer to provide further information.
- Otherwise, this is the most important facet of the VECP process.
- The briefing is normally made to the Program Manager and all relevant stakeholders (finance, technical, logistics and contracts); the activity VE point of contact/expert/advocate should also be included.
  - Coordinate with the Program Manager to ensure the proper attendance (government and contractor).
  - Clarify agenda and discussion topics. Talk with the government counterparts about exactly what people will want to see.
- Desired outcome: Government provides all the feedback necessary for the contractor to submit a VECP and there is buy-in from the Program Manager.
  - This feedback should be worded carefully so that an "approval contingent on the additional information being provided" is not implied. The government cannot imply approval at this point, it can only indicate level of interest and potential areas of concern or suggest information to be

provided. Also, the contractor is not obligated at this point to provide anything.

  - Through discussion with the government, the contractor gains insight into what information would be helpful for the government to make a technical and contractual decision on the VECP.
  - There is usually a lot of interaction at the meeting. It is important for the contractor to deal with questions on negative impacts (if any) by showing how far the benefits outweigh them.

- Maintain interaction with the government as needed while the VECP is being prepared (important for both parties).
  - Usually the contractor responds to questions or concerns. These could be logistics impacts or questions about testing, or the government may want to include something else in the VECP. These do not always result in another briefing, but if required, the Contract Administrator or Program Manager would arrange for it.

d. Government Expresses Support for the VECP

The government must evaluate the idea from a technical and financial perspective. All technical, cost, and logistics concerns should be communicated to the contractor at that time.

- The Program Manager or his representative should tell the contractor how to modify the idea to make the VECP more acceptable.
- The Program Manager should be unambiguous about the desire for a formal VECP.

3. VECP Approval

Figure 18 illustrates the process for VECP approval.

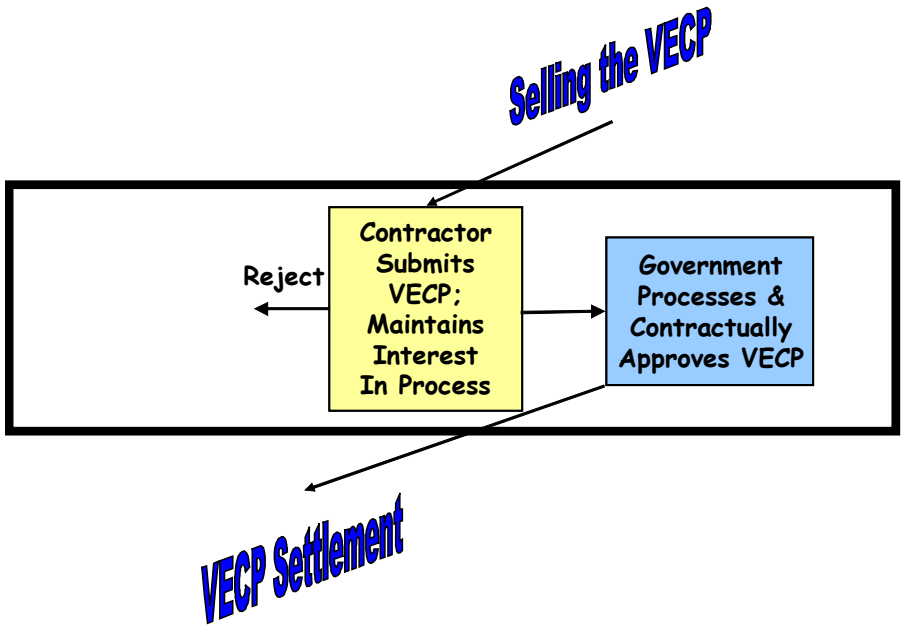

Figure 18. VECP Approval

a. Contractor Submits VECP

Once there is concurrence on the scope of the VECP, the contractor should expedite the in-house preparation of the formal VECP and provide it to the customer as soon as possible after briefing the Program Manager.

- The contractor should work as the contract requires until the contracting officer approves the VECP.
- The VECP is submitted at least to the PCO with information copies to the Administrative Contracting Officer, VE point of contact, and Program Manager, in addition to any other contractually required distribution.
- If the contractor perceives reluctance on the part of the contracting officer to accept a VECP, it may be a good idea to also send a copy to the overall VE lead for the Command or Component. Because of the greater levels of attention being placed on VECPs, keeping higher headquarters informed can only help. If processing problems are encountered, it may be possible for higher headquarters to help resolve the issue.

- In the formal submission (often in the cover letter), the contractor should identify terms and conditions and associated rationale for VECP acceptance, share period, savings share, and any required government investment.
- The Preliminary VECP no longer exists, although some program offices still use the term. It evolved from a time when configuration-management military standards (MIL-STDs) existed. The last MIL-STD on Configuration, MIL-STD-973, was canceled several years ago with Acquisition Reform. Under MIL-STD-973 and its predecessor standards, contractors could use Preliminary ECPs to propose a change. They were done before all the engineering was complete, but usually after there was enough data to show that the change was, or could be, viable. Preliminary ECPs also included a price. From this evolved the idea of a Preliminary VECP. It was defined as "a full up proposal that included a firm price (or Not to Exceed price), a technical description of the change (including testing or qualification requirements)," and eight other required elements as describe in the VE clause, FAR 52.2481(c). The only thing it did not contain was the actual drawing or configuration changes of the final record ECP or the testing results. Such a submittal would now be a formal VECP.

b. Contractor Maintains Interest in the Process

The contractor should try to find a "champion" in the government program office (someone who supports the change) to expedite action on the VECP. The VE point of contact may be the champion.

- The contractor should continue to communicate with the government through the "champion" to check on status and provide answers to questions.
- Sometimes the contractor's local Defense Contract Management Agency can help remind the government program office that it needs to act on the VECP to obtain the maximum savings.

c. Government Processes and Contractually Approves VECP

Using an Integrated Product Team to concurrently address all the VECP issues can expedite the government process. The Program Manager can assist if obstacles occur.

- The VECP must be technically approved as being able to meet the functional requirements.
- The sharing rate will not have to be negotiated if one has previously been agreed upon. If there has not been a previously agreed upon sharing rate, the PCO may consider information (from the Integrated Product Team) such as amount of risk undertaken by the contractor that will help him or her negotiate a fair sharing rate.

- The contract modification approving the VECP enables the contractor to begin work. The PCO can approve or settle the VECP in several ways.
- The PCO can negotiate the rate, settle the VECP, and issue a contract modification.
- The PCO can issue an unpriced order with a not-to-exceed amount cited on the modification and a guaranteed unit savings to be paid by the contractor. This approach may be necessary to meet customer schedule needs and capture high-production quantities. The FAR VE clause recognizes this and, by implication, encourages the government to accept the VECP technically and then complete any pricing negotiations in a subsequent modification to the contract.
- The government may also establish a not-to-exceed limit on contractor VECP development and implementation costs as well as establish a not-less-than savings and a not-to-exceed on government investment. This is usually done when there is a need to expedite VECP implementation and contract modification to ensure that the changes are made on imminent production units.
- When the development and implementation costs exceed the savings on the instant contract, the VECP is implemented through a negative instant contract modification. This means that the government increases the contract by the amount of the negative savings as specified in the FAR part 48. While the contract price should be increased to cover the negative instant contract saving, it often does not happen because the government does not have the money. There are ways around this, such as the contractor accepting the risk associated with the negative instant contract savings with the understanding that it will be recognized in the next production lot (if there is one) or delaying settling the VECP until the next award so that there are enough savings on the two contracts to avoid any negative instant contract saving.
- Finally, if there is a need to expedite implementation of the VECP, the contracting officer can grant approval to implement the VECP through an undefinitized contractual action or via a Contracting Officer's initial modification per FAR 52.248-1(h). This type of Undefinitized Contractual Action[113] has been addressed in a letter from the Director of Defense Procurement. The letter said that an Undefinitized Contractual Action to

[113] An Undefinitized Contractual Action is a new procurement action entered into by the Government for which contractual terms, specifications, or price are not agreed upon before performance is begun (letter contract or change order). Letter contracts and change orders await negotiations to definitize prices. An unpriced change order also may be used. An unpriced change order is a change issued within the general scope of, and under the terms of, the contract, for which contractual terms, specifications, or price are not fully agreed upon before performance is begun.

technically accept a VECP and permit the contractor to apply the VECP to as many units as possible—thus maximizing VE savings—is acceptable and not to be counted against a contracting office's goal of reducing Undefinitized Contractual Actions to a low level.[114]

Formal VECP implementation and government final acceptance of the change are subject to the change passing technical qualifications.

4. VECP Settlement

Figure 19 shows the settlement process.

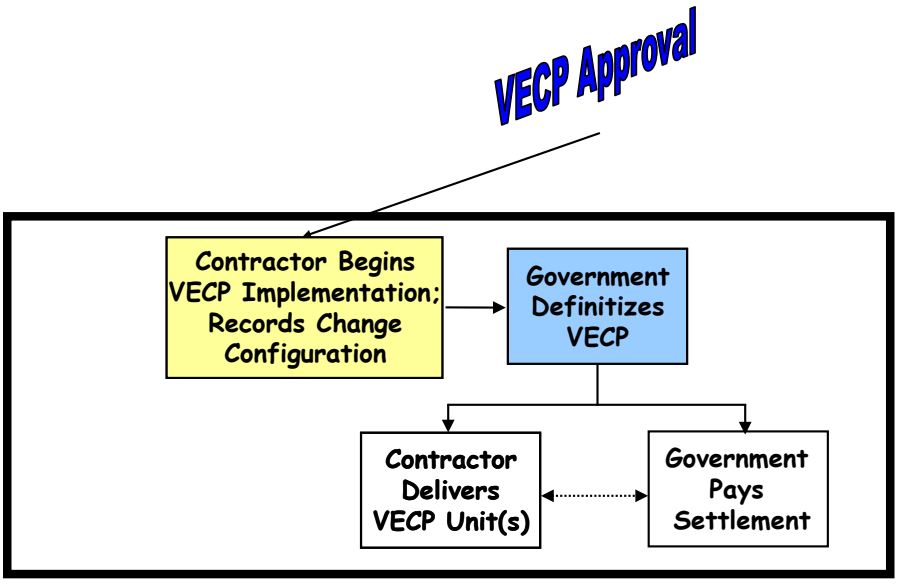

Figure 19. VECP Settlement

a. Contractor Begins VECP Implementation; Records Change Configuration

As a part of the VECP implementation process, the contractor must record the ECP that changes the drawing to incorporate (or allow) the VECP configuration on contracts where the government retains configuration control. It is usually the last step because it is done after the change has been completed and the new drawings are finalized.

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[114] A copy of this letter can be found in Appendix A of Jay Mandelbaum and Danny L. Reed, *Guidebook for Using Value Engineering Change Proposals in Supplies or Services Contracts*, IDA Document D-3046 (Alexandria, VA: Institute for Defense Analyses, October 2006).

b. Government Definitizes the VECP

Definitizing implies reaching an agreement on future per-unit savings and the schedule for repayment of nonrecurring expenses and other upfront contractor/government investment.

- The definitizing contract modification generally occurs on the first contract where a VECP unit is delivered.
- Expeditious processing encourages additional VECPs from the contractor. An alpha contracting process is helpful.
- This is a PCO action with assistance from Program Manager/Integrated Process Team/VE point of contact.
- The contractor's value proposition should be accommodated as much as possible.
- Administrative requirements should be minimized.

C. Concluding Comments

Increasing VECP usage is in the best interest of the government and industry because it improves industry's bottom line and reduces government cost while delivering greater capability to the warfighter. Many contracting officers, program managers, and their contractor counterparts see only a few VECPs in their career. Therefore, it is important for both the government and industry to build upon this expertise, learn from others, and share best practices to formulate and implement VECPs. A knowledge-based CoP is one of the most effective mechanisms to facilitate such sharing. Once people begin exploiting the opportunities provided by VECPs, their use will become self-perpetuating.

Appendix A
Abbreviations

ACO	Administrative Contracting Officer
AEOG	Automated Electrolytic Oxygen Generator
AIMS	Automated Image Intensifier Measurement System
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AoA	Analysis of Alternatives
AT&L	Acquisition, Technology, and Logistics
AVUM	Aviation Unit Maintenance
A/E	Architecture and Engineering
BPR	Business Process Reengineering
CAA	Contingency Automated Application
CAIV	Cost As an Independent Variable
CDR	Critical Design Review
CLIN	Contract Line Item Number
COAST	Common Organizational Level Armament Support Tester
CoP	Community of Practice
COTS	Commercial-off-the-shelf
CP	Compromise Plan
DAU	Defense Acquisition University
DFAS	Defense Finance and Accounting Service
DLA	Defense Logistics Agency
DOD	Department of Defense
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DSC	Dual Stabilator Controller
DSRA	Docking Selected Restricted Availabilities
ECAT	Electronic Catalog
ES	Equipment Specialist
ESA	Engineering Support Activity

FAR	Federal Acquisition Regulation
FAST	Function Analysis System Technique
FCO	Fast Cook-Off
FHC	Final Hazard Classification
FMTV	Family Medium Tactical Vehicle
FY	Fiscal Year
IDA	Institute for Defense Analyses
IDIQ	Indefinite-Quantity-Indefinite-Delivery
IIT	Image Intensifier Tubes
IM	Insensitive Munitions
IRU	Inertial Reference Unit
LRU	Line Replaceable Unit
JIT	Just-in-Time
JSOW	Joint Stand-Off Weapon
LCC	Life-Cycle Cost
LEFRA	Leading Edge Flap Rotary Actuator
LERP	Life Extension Refurbishment Program
LH	Labor-Hour
LSS	Lean Six Sigma
MBFP	Maximum Benefit Federal Plan
MCA	Material Condition Assessment
MIL-STDS	Military Standards
NATO	North Atlantic Treaty Organization
NAVFAC	Naval Facilities Engineering Command
NSSMS	NATO SEASPARROW Surface Missile System
O&S	Operations and Support
OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget
OTWT	Output Traveling Wave Tube
PBL	Performance-Based Logistics
PCO	Procuring Contracting Officer
PDR	Preliminary Design Review
PHD NSWC	Port Hueneme Division Naval Surface Warfare Center

QFD	Quality Function Deployment
RFP	Request for proposal
SEP	Systems Engineering Plan
SKOT	Sets, Kits, Outfits, and Tools
STANAG	Standard Agreement
TAS	Target Acquisition System
THAAD	Terminal High Altitude Area Defense
TCI	Time Change Interval
TDP	Technical Data Package
T&M	Time-and-Material
TOC	Theory of Constraints
TQM	Total Quality Management
TRIZ	Theory of Inventive Problem Solving
UMARK	Unit Maintenance Aerial Recovery Kit
USACE	United States Army Corps of Engineers
VA	Value Analysis
VE	Value Engineering
VECP	Value Engineering Change Proposal
VEI	Value Engineering Incentive
VEP	Value Engineering Proposal
VEPR	Value Engineering Program Requirement
WRA	Weapon Replaceable Assembly