Knowledge and Commitment

(see page 2)
1989

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Knowledge and Commitment —
A New Approach to Chapter Meetings
by Richard J. Park, PE, CVS, FSAVE

Control Charts for the Value Analyst
By Lu Anna Deming & D.H. Miles, Ph.D.

Value Engineering Contract Support Services
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All papers have been edited — frequently condensed — by the editor.
Knowledge and Commitment —
A New Approach To
Chapter Meetings

By Richard J. Park, PE, CVS, FSAVE

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Introduction

SAVE is a relatively small society. Most of our larger chapters are less than 100 members. Even though we may get an excellent turnout at chapter meetings on a percentage basis, compared to larger societies such as SME, NAPM etc., a 20 percent turnout may only amount to 10 to 15 people. This makes it difficult to bring in speakers who in most cases would like to have a substantial number of people in the audience to justify their effort.

In spite of these facts the Detroit Chapter has consistently had excellent meetings over the past years. There is a small group of committed people who come every month because they know the time will be well spent. They will learn something that will benefit them on the job or in their lives. There are some who have learned that the scope of VE is broad enough to assure this benefit.

To assure the future of VE we must bring in new people to carry on the principles and discipline. The question is, therefore, how can we attract more people to our meetings, convince them of the worth of our organization and obtain new members committed to VE and the future so that SAVE and VE can grow in strength and influence?

A New Meeting Format

It has become increasingly evident that a small group of 10-20 people make a discussion group very practical. Although the speaker may come prepared with a formal presentation the small congenial group makes discussion and the interchange of ideas practical during the presentation. After several meetings developed into this format it became apparent that it might be advantageous to design the meeting around the discussion group.

During my years on the National Board I had heard my friend Jack Jonelis refer to Ben Franklin and some of his attitudes and accomplishments. At one point, a creative flash hit me and I decided to consider a method Ben Franklin developed to discuss ideas that have resulted in major contributions to the well being of Society. We are still reaping benefits from some of the ideas developed during these discussion groups. One with which we are all familiar is the Free Public Library.

After some thought as to why our discussion meetings were so successful and learning a little about Ben Franklin I decided to design a meeting around his "Junto." The result, a meeting format flexible enough for both small and larger groups; one from which everyone can benefit. One that will work for larger chapter groups of 30 participants to small scattered

To assure the future of VE we must bring in new people to carry on the principles and disciplines.

It seems that the first fact to be considered is that 10 to 20 members will be the usual number of attendees at a regular monthly meeting and we must plan for that. A second question is: must there be a regularly scheduled monthly meeting? My feeling is that the answer is yes. Regularly scheduled monthly meetings create a habit that is usually planned for. The next question then is: what type of meeting should we hold?

1. See page 6 and 7 Value World Vol. 10 #3, Oct/Nov/Dec 87 "A Way To Improve Chapter Meetings" by John A. Jonelis, PE, CVS.
groups such as Glen Adams has been struggling with for years. I decided to name the format a Franklin Forum.

Ben Franklin

Ben Franklin was born in Boston in 1706. He emigrated to Philadelphia in 1723 when he was only 18 years old. He happened to make a move to the right place at the right time. By 1727 at the age of 22 he was a well known, highly respected citizen.

His trade was printing but during his lifetime he expanded his interests widely. Statesman, scientist, philosopher were among some of the titles he earned. It is the opinion of many that he was one of our greatest Americans. His contribution in science included electricity, weather, oceanography and many inventions. He was a statesman and ambassador and is the only American to sign all four of our great documents, The Articles of Confederation, Declaration of Independence, Constitution and the Treaty with England. He is one we can learn from.

It is the opinion of many that he was one of our greatest Americans.

In 1727 his knowledge and advice was widely sought. As a result he formed his Junto, defined by Webster as a closely knit group of persons combined for some common purpose usually meeting privately. It was actually a small club of leaders in Philadelphia. They surrounded Franklin and were eager to learn from him and from each other. The objective was to contribute to the good and well being of society.

Franklin Forum Formula

The format is simple. A list of subjects of interest to members is developed. Periodically, a member or guest presents a paper on one of the topics of interest to the group. The paper is developed over a period and adequately covers the subject. During the preparation, members also study the subject and come to the presentation prepared to intelligently discuss the presentation. It is a participative discussion from which both the presenter and the group benefit.

Papers can be scheduled for every month, quarterly, or whatever may seem to be beneficial. Small wide-spread chapters can plan an overnight meeting at different locations. The format is flexible and offers substantial benefit to participants.

It should not be expected that a Franklin Form will develop without considerable effort and guidance.

The programs we have tried have shown some shortcomings. The groundrules outlined here are based on our observations and is only a place to start. Modifications may be required to develop a system that fits your needs.

The format is flexible and offers substantial benefit to participants.

Groundrules:

Select A Program Moderator

Presentation 30-40 minutes
- Highlight salient points
- Discuss supporting material
- Cite conclusions

Discussion
- Moderator opens floor for questions to the speaker.
- Moderator regulates discussion to assure everyone has an opportunity to express his/her idea.
- If the program doesn't generate discussion, so be it, terminate the meeting.
- Limit the meeting to 1½ hours unless there is a consensus by the group to continue.

Notes
A secretary should take notes for distribution; SAVE journals, newspaper releases or just for the benefit of participants.

Scope of Franklin Forums

It is possible that the Forums can result in improved papers for conferences and publications. It is also possible to select the best paper of the year for a National Franklin Forum at the Annual Conference. Participants could also be selected as Franklin Forum Scholars, a National Honor Society.

It is possible that the Forums could result in improved papers for conferences and publications

Summary

The Franklin Forum format lends itself to both small and large groups. It also provides a means for commitment on the part of members who participate and a way for small far-flung chapters to develop a beneficial relationship. Successful programs in chapters can be introduced to the National Conference. Franklin Forum papers can include the presenter and the original discussion group.

A start is necessary and only worthwhile presentations and a group committed to make the program work for mutual benefit will achieve success. As I see it, everyone can win and the result may be spectacular.
Control Charts for the Value Analyst

By Lu Anna Deming and D.H. Liles, Ph.D.

Mrs. Deming is pursuing her masters degree in Industrial Engineering at The University of Texas at Arlington, after receiving her bachelors degree from Michigan State University. She is concentrating her studies in the applications of statistical quality control in manufacturing processes. She is a member of SAVE, IIE, and Alpha Pi Mu, honor society for industrial engineering students.

Dr. Liles is on the faculty of Industrial Engineering at The University of Texas at Arlington. He has primary responsibility for undergraduate and graduate courses in statistical quality/process control, production and inventory control, and computer integrated manufacturing. Dr. Liles has contracts with local industry for statistical control and has three Ph.D. students pursuing related research. Dr. Liles is a member of five professional societies and three honor societies.

Introduction

The basic purpose of Value Analysis (VA) is "the efficient identification (and elimination) of unnecessary cost" while the basic purpose of Statistical Process Control (SPC) is "to manage quality and maintain assurance of continued high quality." SPC does this by identifying and eliminating manufacturing error. While not at cross purposes, these goals are not exactly the same. Yet both VA and Quality Control specialists can use many of the same tools to achieve their objectives. One of these tools is the Shewhart Control Chart.

VA involves four basic steps.

1. Accumulating data and identification of problems.
2. Analysis of the data to determine areas of greatest cost reduction.
3. Create solutions, consider alternatives.
4. Judge the solutions and determine the best ones. Recommend action.

The Shewhart Control Chart can be very useful to the Value Analyst in three of the four steps. When the Value Analyst is called upon to work in an environment where there is an existing Quality Control department, the analyst can use existing Control Charts in his study without having to go to the trouble of collecting new data, thus saving time and expense in the data collection stage (step 1). Control Charts can be used to indicate areas of opportunity for cost reduction (step 2), and can be used to statistically confirm the results of a decision (step 4).

This discussion focuses on cost opportunities as they relate to the manufacturing process used to create the part or product. This may include topics on materials as they relate to processing time or processing cost, but will not cover cost opportunities as they relate to the material cost itself or incoming material quality.

The cost opportunities we are discussing may be thought of as a continuing line beginning at one end with a process that is not capable of meeting specifications. This line continues through the other end to a near perfect process. There are two costs associated with such a line, scrap and rework costs and quality costs.

The cost opportunities we are discussing may be thought of as a continuing line beginning at one end with a process that is not capable of meeting specifications.

Scrap and rework costs involve material loss, labor productivity loss, machine time loss, equipment wear loss, and testing and inspection costs to detect...
defective product. Other costs which are not as easily identifiable include loss of market share or low prices to the consumer due to an inferior product. As the process is improved, these costs decrease.

The improvement of the process incurs certain quality costs. These costs may include the more expensive machines and the more highly skilled labor needed to eliminate error and produce higher quality.

It is the VA's job to determine the point of minimal costs along this continuum. Control charts are a tool to help identify the presence or absence of these costs.

**Review of Statistical Control**

SPC uses the Shewhart control chart to evaluate the behavior of the manufacturing process. The basic premise of SPC is that if certain process parameters are well behaved then product quality is assured.

Statistical control theory assumes the existence of two kinds of process error or variation. The first, natural or random variation, is inherent to the process and is, therefore, very difficult to reduce or eliminate. The second, systematic error, is caused by some explainable process irregularity. The control chart is a statistical test that identifies systematic error. Control charts are used to detect and correct process irregularities that would otherwise cause product nonconformance. The term "in control" implies the absence of systematic error.

The term "in control" implies the absence of systematic error.

The behavior of any manufacturing process parameter can be described in terms of process accuracy and process precision. Accuracy has to do with process centering. Precision has to do with the absence of systematic error. Control charts are used to help identify the presence or absence of these costs.

**Example**

The following is an example of how a process capability study might be used by the value engineer to identify opportunities for cost savings.

The subject of the study is the length of a piece of wire that is used as a component. The study plan specifies that a sample or subgroup be collected from the wire machine at a randomly selected time, once per hour. Each sample consists of the five pieces of wire produced immediately prior to the sample time (consecutive, order of production subgrouping). For each sample, the sample statistics XBAR (sample average) and R (sample range) are calculated. The data and statistics for 25 samples or subgroups are shown in Table 1.

**Table 1**

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<th>MEMBER2</th>
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The first step in a capability study is to analyze the error of both the process centering and process dispersion. This begins with control limit calculations (UCLs, LCLs) or the sample ranges (process dispersion).

**R Chart**

\[ \text{UCL}_R = D_4 \times \text{RBar} = 2.114 \times (0.43018) = 0.9094 \]

\[ \text{LCL}_R = D_3 \times \text{RBar} = 0 \times (0.43018) = 0 \]

**Note:** \( D_3 \) and \( D_4 \) are known tabulated constants that are a function of subgroup size. RBar is the average of the sample ranges.

Comparing the range statistics shown in Table 1 to these control limits, it is concluded that process dispersion is "in control." This comparison is shown in Figure 1. From the earlier discussion, it should be remembered that "in control" implies the absence of systematic error. If one or more points were found to be "out of control" the corresponding systematic error would have to be isolated and eliminated before the study could continue. Given this "in control" indication, the process dispersion can be quantified using the estimated process population standard deviation (\( \sigma \)).
Given a controlled dispersion, process centering can then be evaluated. This is accomplished using control limit calculations for sample averages.

**XBAR Chart**

\[
UCL_{XBAR} = \bar{X} + A_2 (RBAR)
\]

\[
= 4.98572 + (0.577) (0.43018)
\]

\[
= 5.23393
\]

\[
LCL_{XBAR} = \bar{X} - A_2 (RBAR)
\]

\[
= 4.98572 - (0.557) (0.43018)
\]

\[
= 4.73751
\]

NOTE: \(A_2\) is a known constant. \(\bar{X}\) is the average of the sample averages.

Comparing the sample averages shown on Table 1 with these control limits, indicates that the process centering is also “in control.” As above, the presence of systematic error would have to be resolved before continuing. The XBAR chart is shown in Figure 2. Given this “in control” indication, the process populations mean (\(\mu'\)) can be estimated using XBARBAR.

\[
\mu' = XBAR \times XBAR = 4.98572
\]

The final step in a capability study is to compare the behavior of the process to product requirements as expressed by tolerances or specifications. There are at least two ways to make this comparison. One approach is to compare the population of individual parts (as defined by \(\mu'\) and \(\sigma'\)) directly to the specifications. A more convenient approach, perhaps, is to make the comparison using modified control limits (also called reject limits). The advantage of using modified control limits is that they are comparable directly to control limits and sample averages whereas specifications are not. (NOTE: specifications control the behavior of individual units of the population of product. Control limits and modified control limits are compared to the behavior of the XBAR sample statistic.) If the control limits are found to be within the modified control limits, then it may be concluded that the population is within specifications.

Modified control limits are defined as:

\[
UML = \text{Upper Specification} - 3\sigma' + A_2 (RBAR)
\]

\[
LML = \text{Lower Specification} + 3\sigma' - A_2 (RBAR)
\]

The comparison between control limits and modified limits may yield one of three basic conclusions.

**Conclusion 1:** The process is marginally capable of meeting requirements. This is concluded when the XBAR control limits and the modified limits are approximately the same.

For example, suppose that the specifications on the piece of wire are 5.55 and 4.45. The modified limits are then calculated as:

\[
UML = 5.55 - 3 (0.1849) + (0.577) (0.43018)
\]

\[
= 5.2435
\]

\[
LML = 4.45 + 3 (0.1849) - (0.577) (0.43018)
\]

\[
= 4.7565
\]

In this case, the modified limits and the XBAR control limits are approximately the same. This indicates marginal capability. As shown in Figure 3, the population of individuals is, indeed, marginally within specifications. This situation indicates that scrap and rework costs are not large and that the opportunity for quality cost reduction is limited.
Conclusion 2: The second of the three basic conclusions is made when the modified limits are found to be within the XBAR control limits. Suppose that the specifications for the product are 5.35 and 4.65. The modified limits are therefore:

\[ \begin{align*}
UML &= 5.35 - 3(0.1849) + (0.577)(0.43018) \\
&= 5.0435 \\
LML &= 4.65 + 3(0.1849) - (0.577)(0.43018) \\
&= 4.9565
\end{align*} \]

Comparing these modified limits to the original XBAR control limits indicates that the process is not capable. Figure 4 confirms that a large percentage of the population does not meet specifications. In this case the precision of the process is not adequate to meet product requirements.

When this condition occurs, the analyst must first determine if the specifications are related to real requirements (either to fit with another part, or as demanded by the customer) or are arbitrary. Arbitrary requirements usually originate at the design stage when the process or product is new; now historical data exists to establish specifications. If the specifications are found to be arbitrary, the analyst should suggest realistic specifications that are within process capability.

If, however, the specifications are found to be realistic, the analyst should investigate the availability of other processes, other materials, or other methods that may improve the process.

If other processes or materials are available, the cost of these processes and materials should be evaluated against the increased value of the product. If other processes or materials are unavailable, then the situation will have to be endured. This implies continued sorting of product and the resultant rework and scrap. The analyst should be aware that some specifications are tight because of subsequent assembly requirements. If this is the case, investigation should include the later stages of the process. This step may result in loosening the specifications on the original part after modification of the whole process.

A second similar condition may be observed when a process centering problem exists relative to the specifications. This condition, as illustrated in Figure 5, should indicate to the analyst the need to recenter the process.

Conclusion 3: The third basic conclusion is made when the control limits are found to be well within the modified limits. This indicates that the process is more than capable of meeting requirements. Suppose that the specifications for the product are 5.75 and 4.25. The modified limits are then:

\[ \begin{align*}
UML &= 5.75 - 3(0.1849) + (0.577)(0.43018) \\
&= 5.4435 \\
LML &= 4.25 + 3(0.1849) - (0.577)(0.43018) \\
&= 4.5565
\end{align*} \]

As shown in Figure 6, the population is, of course, more than able to meet the requirements. This situation may also present the analyst with the opportunity for reduction in costs thru analysis of what is, in effect excess quality.
Summary

As we have shown, control charts can be a very useful and convenient tool for the Value Analyst to use in the identification and elimination of unnecessary cost. In the first step, accumulating data and identifying problems, control charts can provide assistance in two ways. First, if there is existing quality control available, the Value Analyst will not need to collect new data, but can use existing data from that department. In the second, control charts can identify problem areas by indicating if a particular process is not “in control.”

In the second step, determining areas of greatest cost reduction, control charts can aid in identifying areas where scrap and rework costs are occurring, and also by pointing out areas where quality costs may be significantly higher than the value being generated by the process. For both of these areas, the Analyst will need to apply other tools to determine the relationship between the costs of scrap, rework or quality, and the value of a more perfect product. There will be instances in which the cost of eliminating scrap/rework will be higher than the actual cost of the scrap/rework. In this case, the elimination of this scrap/rework cost will not be feasible with present technology. There will also be many instances, where poor quality will affect sales and profit, and therefore, the apparently higher quality has a very real value. To reduce cost and improve the value of the product, the Value Analyst will need to investigate the ramifications of any changes in either of these areas.

In the last step, that of recommending action, control charts can assist the Value Analyst in presenting his recommendations to the decision maker to aid in making a decision that will be valuable to the future of the product and the company.

Bibliography


References


Overview

There is a considerable task involved in obtaining contractor services for Value Engineering Proposal (VEP) selection, research and preparation, or for workshops or education. With a proper jell between the contractor and the government facility, such a contract can be worthwhile, allowing the facility to accomplish more with less. However, due to certain aspects, because of the peculiar nature of VE, the marriage of a VE Contractor and a government facility can be burdened with delays, a lack of cooperation or activity on either one or both parts, and can end in a disappointing divorce with legal entanglements that are difficult to resolve.

Expectations

VE support services can be used in several ways to prove fruitful:

1. VEP preparation
2. Workshops
3. Education

VEP preparation can be lucrative if properly run and coordinated. Fort Belvoir has several VE contractors, coordinated by a single VE rep. Ft. Belvoir is responsible yearly for a good percentage of the U.S. Army Troop Support Command goal achievement.

VE workshops are perhaps the best executed effort by a VE contractor. During a workshop where I was a monitor, I witnessed the professionalism and pride exhibited by the instructors. There were very few negative remarks by those attending and it proved exciting and beneficial. However, before issuing a contract of this nature, the government facility should take into consideration that workshop follow-ups will be a necessity. If this is not provided by the workshop contract, then the VE office will be responsible for it.

VEP preparation can be lucrative if properly run and coordinated.

VE Education: from the government VE office standpoint, there is an endless array of government classes available. There are agencies that find it more convenient to have a contractor come on site and provide classes similar to the government classes. There are people who would not consider a U.S. Army Management & Engineering Training Agency course, but would attend a contractor performed class. Care must be shown here. Remember, the lowest bidder gets the contract and the results may not be what was envisioned.

Problems

Contractor selection - This is perhaps the most difficult aspect of the whole affair. Who to pick? Actually, the VE Office has little to do with the choice. The lowest bidder of qualified contractors gets the contract. That's the law of procurement. However, the determination of qualification is left to the VE Office.

As you can envision, it could be a marriage of strangers. To prevent working with a stranger from being too much of a blow, consider doing or not doing the following in determining qualifications:

1. Do not combine VE training and VE Proposal preparation on the same contract. There is a world
of difference in the teaching of VE and actual practice. Maintaining a staff of Value Engineers, for producing VE proposals, is a totally different operation than the high level discipline of teaching the theories involved.

The lowest bidder of qualified contractors gets the contract.

2. Do not make the mistake of assuming an engineering company, no matter how much of a technical powerhouse it may be, can perform VE. VE is a field, not a course. Establish the number of working Value Engineers, or Certified Value Specialists, with a company before establishing the company as qualified. Remember, there are contractors who will assure you they can do anything, just to get a contract.

3. Before submitting a list of acceptable VE contractors to procurement, research them. Check with agencies that have used contractor services to learn the pitfalls involved. Some agencies, such as Fort Belvoir, have experienced excellent results using VE support contractors.

4. For VEP preparation, he prepared to spend a great deal of up-front monitoring and coordination. Acquaint the contractor with the areas he will become involved in, the system he will investigate and the groups he will coordinate with. In the contract, spell out what is expected of the contractor.

Do not assume the contractor will automatically perform anything. This is basic to any contract, but especially so in VE.

Do not assume the contractor will automatically perform anything.

5. Be sure your own command is familiar with VE and what the contract will accomplish. One VE office spent almost three years getting a proposal on the street for bid. It was in a fledgling office, in an agency that had experienced little VE exposure. One office issued a time & cost contract that yielded almost nothing in return. For new offices, push to get as many people as possible in Principles and Applications of Value Engineering and Contractual Applications of Value Engineering. These are government courses that are a must.

6. Be aware of what the contractor will provide. If the contractor is not local, assure that there is a local representative for on-base coordination and research. Do not allow yourself to become immersed in coordination & research. Hands on is the contractor's effort. Monitoring is yours.

Conclusion

In this day of a shrinking governmental workforce, the work schedule within civil service agencies will hardly encourage developing VEPs. However, the saving potential will still exist. An efficient VE support service contractor will allow agencies to continue finding those savings and processing the paperwork with a minimum workforce. To be sure, there are potential complications, but if the responsible agency is diligent in searching for a qualified contractor to meet the agency's particular need, and if proper contract monitoring is conducted, a VE support service contract is feasible.
Promoting Supplier Value Engineering

By Irving L. Brown

Irv is a full time Senior Value Engineer with Honeywell's Underseas Systems Division. He has over 30 years in manufacturing process and other value related activity. Irv was first exposed to VE in 1966, and has now put together several Cost Reduction/VE Training Packages, and teaches several seminar/workshops annually. He has conducted several VE Awareness sessions throughout the United States.

Irv is a member of SAVE and Chairman of Subcontractor VE on the Board of the Electronic Industries Association (EIA). He has a large background in Supplier VE and knows the "pitfalls" from personal experiences.

Many large contractors are systems integration houses with the greater part of the product build/cost accomplished through vendors, suppliers, subcontractors or inter-divisional. This makes it attractive to stimulate the major suppliers to submit Value Engineering Change Proposals (VECP's). Even though the prime contractor's share of royalties is reduced, the vast potential of supplier savings makes promoting VE through this source a competitive attraction. This paper describes the challenges inherent in trying to have a viable supplier VECP system.

Awareness Sessions - Management

The probability of a promotion or program having success requires the support of internal management. A creditable salesmanship effort must be performed by VE based on return on investment (ROI). Not only funding and man hour dedication must be sought and committed, but special incentives to stimulate the suppliers may be needed. In some instances there may be no history, or a negative history, to support this promotion. This is where the Value Engineers must research success stories and also prepare some material explaining the rationale for rejected VECP submissions. This last item is addressed later.
A new salesmanship effort, with a great deal of diplomacy, is required to bring a case for VE to the supplier. In several instances we found that the supplier had a bitter experience with VE. This could have been due to customer response or an uneducated approach that turned up negative. A negative attitude could result from a large investment of time and dollars into an idea that was rejected. It could also have resulted from simply being overwhelmed by the documentation requirements. Another factor, of course, is the possibility of exposing a proprietary process. It is wise to get background on the supplier and his management in advance to be prepared to positively address these items.

A new salesmanship effort, with a great deal of diplomacy, is required to bring a case for VE to the supplier.

Having gained the attention of the supplier/s a visit to the facility should be arranged to make a promotion for VE to all interfacing management. This presentation must accomplish two things:

1. Promote and sell active participating in VE by the supplier. Emphasize that their funded effort, with risk, will make them more competitive.
2. Assure dedicated support to the supplier's efforts in VE activity by you the customer. Emphasize that since the suppliers share is based on this impact on the prime contractor's cost, the supplier's share could effectively exceed his cost and profit.

Remember at all times to be up-front and knowledgeable. The group you are addressing may also have to sell your proposal to their management.

Supplier Personnel Training

An immediate demonstration of support and commitment for the supplier program would be the initiation and training of a core of people who will interface the VE program. This would be in the form of your own VE training program, a formal adaption of your own VE knowledge or suggest a creditable consultant. The advantage of the first two alternatives is the lack of cost to the supplier with the exception of employee time and facilities. An acceptable proposal, disagreeable as it might be to the trainees, might by an after hours seminar or partial work time/after hours. A full 40 hour structured seminar should be encouraged to assure understanding and efficient use of the VE process.

Initiate First Supplier Submittal

To complement the training an actual VECP walk-through should be done to instill confidence in VE and avoid unnecessary delays and re-submissions due to documentations inadequacies.

This documentation training, performed by the person or persons who will receive VECPs from the supplier, should be as objective as possible. That is, don't make unnecessary work for them. Some documentation and documentation research for back-up has probably been done by the supplier when determining risk and ROI. Assure that the supplier understands the optimum information required of him. This exercise will also prepare the VECP recipient's system to process future VE documents by creating an attentiveness situation where all participants are aware of the paper process and their responsibility.

Expeditious Follow Up of Supplier Submittals

A major complaint of suppliers is lack of response to their submittals and in some cases lack of knowledge or tracking of submittals.

Each major contractor has its own priorities, interests, and problems. These demands can consume entire departments which makes bonus activities, like supplier VE or VE in general, lose visibility. This unfortunately is the norm rather than the exception! Also, the engineering and administrative staff are more attentive to their own proposals and activity in process than to some supplier input “awaiting attention.” Taking the latter a step further — as long as that document sits in the mail box it won't interfere with internal activity in process. This is where management commitment, well in advance of supplier submittals, must be obtained. Supplier submittals must be inserted into the system with equal visibility as internal proposals.

A major complaint of suppliers is lack of response to their submittals and in some cases lack of knowledge or tracking of submittals.

Keeping supplier VE proposals moving can be a frustrating task. Engineering Change Proposals (ECPs) and VECPs are routed through many departments and many hands. This means many areas where the document can be “pigeon-holed” and simply forgotten.

Avoiding the stalling of supplier VECPs or any VECP is where VE justifies itself and at the same time gains visibility. A reporting system is a must to:

1. Let management know the VE savings potential.
2. Let management know what they are gaining.
3. Let management know what they are losing.

The latter is a strong point. By letting any VECP sit dormant the production volume decreases, having a negative linear effect on the award. The VE department

1. Each VECP is unique and each evaluation will most probably require further communication with an agency, formal or otherwise. Common inadequacies and errors should be high-lighted to assure smoother VECP flow.
is quite probably the only overseer of the VECP process. Along with the awareness preparation, the VE department must:

1. Directly or indirectly (through procurement) be aware of supplier VECP submissions.
2. Assure supplier submissions enter the "mainstream" activity.
3. Act as VECP status source.

Most important, VE must act as the catalyst to establish an ongoing expeditious follow up of supplier submittals.

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**Most important, VE must act as the catalyst to establish an ongoing expeditious follow up of supplier submittals.**

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**Expeditious Payment of Supplier Awards**

This activity rates equal or higher billing than follow up of supplier submittals. The old “you’ll get paid when we get paid” has become a tiresome and destructive term. This is where the customer (prime contractor) supplier interface system must be “fine tuned.” This area requires a paper in itself since the payment goal can be elusive, even from submittals of the prime contract, depending on “negotiation skills.” I feel like I’ve lost the theme of “why did we call this meeting?” so I’ll venture into this as far as my observations have taken me to date.

Let’s go back to the old complaint of “after X” years we’re still waiting to get paid! This has been an ongoing deterrent to supplier submittals. There is really no pat answer, but the issue cannot be side-stepped! Once again the lack of visibility of VE can cause procedural difficulties.

1. Does the project staff know that a portion of the revenues must be set aside for supplier VE?
2. Is a system established to assure supplier compensation for follow-on contracts and royalties?

Both can be deterrents since the control has moved out of the realm of VE and into the hands of the comptroller or finance group. We’re now back to management awareness.

Management can assure supplier compensation by knowing the requirement for re-allocation of revenue. This is important and can be lost in the corporate or divisional finance systems. Even more elusive to the system, is the re-allocation for follow-on contracts or royalty payments. Since I have recommended that the VE department assure supplier interface, lets also assure that they prepare for this potential problem.

The logistics of ascertaining supplier compensation could be:

1. Maintain the Instant Contract price at the same level once the reduced cost change has been installed with a clear contractual commitment that the supplier will return 25% back to the government, through the prime contractor, at the end of the current contract. This can be made attractive to the supplier by high-lighting the use of this savings in “return-on-money” ventures for a time before returning this portion! Or-

2. Since the prime contractor must dedicate extra time and personnel to the bookkeeping and VECP negotiations, there is probably logic to the supplier reducing the price to the contractor upon installation of the change. Since the prime contractor’s price to the customer remains the same, the savings award due the supplier can be returned at the end of the contract. Reimbursement can also be negotiated at six months or quarterly intervals keeping in mind that the bookkeeping effectively involves cost to both parties.

These are only two suggestions of how the Instant Contract award could be handled. The finance group of the supplier and contractor may have several other options, but should be made aware of this so compensation activity flows smoothly.

The first supplier submission will no doubt be a learning experience to submitter and receiver, but should not lack professionalism, which could discourage further submittals.

Assurance of award payments for concurrent and future contracts plus collateral savings must be highlighted by the finance group to assure that the comptroller, or who ever controls revenue, does not allow these dollars to disappear into the financial system. Once the program manager declares them as profit it is difficult to get them back. This finance activity is normally outside the realm of the VE group and I’d prefer to keep it that way, but the finance group can be stimulated and reminded by periodic “Awareness Sessions” and assurance that they are copied on appropriate reports. This aspect of cash flow should be clarified in corporate/divisional policy and approved by all effected Directors and Managers.

This section of this paper seems to be the longest. It also loses direction at times. This may be because lack of “Expeditious Payment” (along with no established method of handling follow-on contract payments) has been the biggest supplier complaint that I have been confronted with while trying to stimulate suppliers. The financial groups who must reimburse the supplier are normally (in large corporations) operating outside Engineering knowledge — VE can be foreign to them. Supplier compensation for VE is not automatically part of the system and therefore must be stimulated by the VE group. Educate yourselves in the finance systems and send your best presenter to get the director (or whomever) in agreement, or this whole project will be a singular “sky rocket” with a burst of activity from the VE group and then nothing.
Develop An Ongoing Supplier Program

An idea goal of an engineer should be to complete a project to the point that it is self-sustaining and move to the next challenge! Continued supplier VE requires vigilance as long as that supplier is active or eligible for your programs.

**Continued supplier VE requires vigilance as long as that supplier is active or eligible for your programs.**

The VE group is highlighted and really shows “payback” when a project is in financial trouble. All resources are utilized including Supplier VE. Supplier VE has been found to be a valuable ally in reducing cost and recovering from cost effective problems. All divisional and/or corporate activity has supported it and the cooperation is smooth and effective.

I highlight this as a preamble leading into inherent pitfalls built into all production operations. Especially where there are many Managers involved.

When cost effective problems are overcome and things are back to “normal,” the groups that salvaged the situation, although hopefully not forgotten, lose visibility. Supplier VE, that was applauded in earlier months, may receive slow or even negative response. This can create a permanent barrier to future submissions.

Soliciting supplier VE, only as a tool to recover from periodic problems, can have a negative effect on the overall ongoing programs. After the “get-well” period is over, in-house and supplier VECPs tend to receive less attention and in fact, verbiage to the supplier can discourage further submittals. The divisional or corporate theme (and this is not unnatural) is to stimulate all sources of assistance during crises and allow them to return to normal activities when the situation is once again under control. An inadvertent impact of this is to place Supplier VE on an equal priority — if not actually recommend no more VE submittals.

The impact of divisional or corporate discouragement of supplier VECPs upon termination of crises is a vehicle for stopping future submittals. Corporations have found that should another crises recur, where Supplier VE activity could contribute significant potential to recover, the suppliers declined to respond with strong reference to previous treatment!

If we, as Value Engineers, are to pursue Supplier VE and its financial potential in savings for both DoD and contractor/supplier sharing we must develop procedures to assure expeditious payment of supplier awards and an ongoing supplier program.

**Awareness Session - Customer**

Assuming all our efforts pay off and our suppliers begin an intensive VE program, the Government contracting agencies might be surprised at a sudden deluge of VECP submittals.

The government agencies may not have enough staff for your program and this can cause the delays we told the suppliers we were trying to avoid. Also, the customer will wonder “what is going on” when there is suddenly a lot of VECP activity. He might think something was held back during contract negotiations and exposed later to “rip-uncle-off.”

Your company’s engineering interface people should be made aware of the VECP activity since they deal with the technical agencies where technical approval must come from. The contract negotiator must also be in the communications link since he is the one who will do the negotiations for the actual awards. These groups can formally or informally notify the customer in advance to avoid surprises.
Is There Value In Automation?

by Joseph V. Lambert, CVS

Mr. Lambert, CVS, is a member of the VE Professional Staff at Martin Marietta Electronics & Missiles Group, Orlando operations. He is responsible for the VE activity on several complex weapon systems programs and has Co-Authored a VE manual for VE workshops. Mr. Lambert has a B.S. degree in Business Administration from Florida Southern College. He has more than 20 years experience in corporate management, industrial engineering, and production line supervision. Mr. Lambert is Director of Development for the Central Florida Chapter of SAVE.

Introduction

When asked, “Is There Value in Automation?,” most of us would respond affirmatively. I believe that most companies automate because management feels that there is value. My thesis, however, is that there is value in automating, if the result provides a good return-on-investment (ROI).

Net savings and ROI are the usual criteria for determining whether an idea is worth implementing. My experience has been that exhaustive investigation before investing in automation can pay great dividends.

Companies, especially those with large capital budgets, usually automate production of existing designs to meet shipping schedules, and to become more price competitive. In so doing, we fall into a trap! To automate existing designs simply to reduce cost, without first analyzing the design to identify the function of the product and to establish its functional worth, may not be realistic. First, we should consider function and functional worth from both the company’s and customer’s perspective, and then proceed.

Definition of Value

Value is “the monetary worth of something. Most people would agree with this definition; however, it doesn’t lend itself to problem solving. The Value Engineering (VE) definition lends itself to problem solving by identifying value as: the lowest cost to reliably provide the required functions or service at the desired time and place and with the essential quality. This definition forces one to determine what the basic function is worth to the user.

There is also an intangible aspect about the value of automation. Will the automation eliminate process problems on the manufacturing floor? This consideration cannot be overlooked. Eliminating problems on the manufacturing floor provides added benefits of improved morale, job interest, and the knowledge that the company cares about its employees. Absence of this company concern creates an environment that spawns unrest and discontent.

Most of us want to feel that our efforts are needed, and that our work is important. Automation can create employee unrest if it creates feelings of “being replaced by a machine.” This attitude is deeply rooted and spreads quickly through the manufacturing floor. Employee involvement and an awareness of plans and reasons for automation can help make the idea of automation more acceptable.

Case History

Management decided to automate a switch-line producing approximately 90,000 units per month, on the assumption that automation would cut costs and increase profit.

Further, after concluding that pinning a cover on the switch was a major problem, the company allocated $60,000 to solve what seemed like an easy problem; but, the problem proved to be more difficult and expensive. It eventually cost $88,800.
The original operation was conducted as follows (Figure 1):

![Figure 1. Exploded View of Switch](image)

The switch had a phenolic base and cover. The cover was placed on the base, and holes were drilled through the cover into each of the base sides. Each side was drilled, one hole at a time, on a table-mounted drill press. Next, the switch was taken apart to clean out the drill dust.

Removing all the dust from every switch was almost impossible. As a result, the switches with drill-dust residue operated intermittently and had to be subjected to high voltage for a fraction of a second to burn the dust off the contacts. Next, the covers were secured to the base with tapered, knurled pins. The pins were pushed through the cover hole and into the base by an arbor press. This operation was time consuming and produced broken covers and cracked bases. The assembly time for these operations was 1.3 minutes per switch. The scrap was 12 percent for the bases and 16 percent for the covers.

Through trial and error a semiautomated operation evolved. A semiautomatic machine was designed and built to simultaneously drill the base holes to a predetermined depth. The actuator button was placed into the cover. The cover was assembled to the base and the switch assembly was transported to another semiautomatic machine. Here the switch was placed on a gravity-feed track, and moved to a station where stranded wire was cut off at 0.040 inches and shot into the cover and base by heavy duty commercial sewing machine heads. This operation was an improvement over the original method. Tables I and II provide process and cost comparisons.

Table I. Process Comparison

<table>
<thead>
<tr>
<th>Original Operation</th>
<th>Semiautomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Drill switch base, using bench press one side at time</td>
<td>Drill both sides simultaneously</td>
</tr>
<tr>
<td>2 Wash</td>
<td>Same</td>
</tr>
<tr>
<td>3 Assemble button to cover</td>
<td>Same</td>
</tr>
<tr>
<td>4 Assemble cover to base assembly</td>
<td>Same</td>
</tr>
<tr>
<td>5 Drill one side, turn unit, drill other side</td>
<td>Drill both sides simultaneously</td>
</tr>
<tr>
<td>6 Remove cover, blow out dust</td>
<td>Same</td>
</tr>
<tr>
<td>7 Hand press pin in one side, turn switch over, press pin into other side</td>
<td>Both sides pinned simultaneously</td>
</tr>
</tbody>
</table>

Table II. Cost Comparison

<table>
<thead>
<tr>
<th>Original Operation</th>
<th>Semi-Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor hours</td>
<td>0.0217</td>
</tr>
<tr>
<td>Labor rate</td>
<td>$6.00</td>
</tr>
<tr>
<td>Labor cost</td>
<td>$0.13</td>
</tr>
<tr>
<td>Switch cover</td>
<td>$0.045</td>
</tr>
<tr>
<td>Scrap dollars</td>
<td>$0.0144</td>
</tr>
<tr>
<td>Total</td>
<td>$0.1894</td>
</tr>
<tr>
<td>Switch savings</td>
<td>$0.1894 - $0.1394 = $0.05</td>
</tr>
</tbody>
</table>

Table III. ROI Computation

\[
\text{ROI} = \frac{\text{Profit}}{\text{Investments}} = \frac{-x \cdot \text{Sales}}{x \cdot \text{Investments}}
\]

<table>
<thead>
<tr>
<th>Profit</th>
<th>Sales</th>
<th>$52K</th>
<th>$457.6K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>$52K</td>
<td>$457.6K</td>
<td></td>
</tr>
<tr>
<td>Investments</td>
<td>$88.8K</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{ROI} = \frac{-x \cdot \text{Sales}}{x \cdot \text{Investments}} = \frac{52K}{457.6K} = 0.586
\]

Considering the highly competitive nature of the business, the decision was to automate despite the low ROI. But, ROI does not tell the whole story. The effective yield and throughput were not very good because rework and scrap had not been eliminated. Many problems were just shifted to a semiautomatic operation rather than solved. This scenario is quite common since there is the tendency to overlook functional worth. In problems with hardware, companies immediately think automation is a solution.
In problems with hardware, companies immediately think automation is a solution.

Value Engineering Approach

I started my assignment by doing analyses of the products. I found that one switch type was the single most high-volume unit made. Its sales were 55 percent of the switch business and the biggest profit-maker. The question was how to improve profit since a part of the assembly process had already been semiautomated.

Competition was so strong that raising the selling price of the switch was ruled out. The only other option was to reduce factory cost. So, I formed a team composed of the purchasing manager, production foreman, tool-maker, engineering technician, and quality control person. The explanation of what needed was met with blank stares. Finally, the tool maker said, “We just got that switchline settled down and running well. There’s no way that this group can make any improvements in it!” This was an honest opinion expressed by an individual close to the problem; but, I had to convince the team members that value analysis (VA) would work. The key is to follow the job plan.

Ultimately, we agreed to employ the VA technique. The team went through the information phase and the “light came on” when the speculation and creativity phases were over. A functional analysis was done to determine the most cost-effective way to reliably accomplish the products function.

As indicated in Figure 2, the FAST diagram, the basic function of the switch cover was to “PROTECT SWITCH.” The function of the pin in each side was to “SECURE COVER.” The pins were needed only to hold the cover to the base. Pinning the covers was a problem because:

1. Pin could crack the cover
2. Pin could crack the base
3. Pin could seat only part-way and jam in the machine track
4. Machine could malfunction, and drive in only one of the two pins

The following changes were identified by VA:

1. Change cover materials to Lexan
2. Redesign cover to snap-on to base to eliminate the need for drilling and cleaning out dust.
3. Redesign the base with a window to accept ears of snap-on covers.

The benefits were:

1. Reduced labor
2. Improved reliability
3. Reduced scrap
4. Covers that could be removed when the switch had to be readjusted after test.

The new assembly procedure was changed to:

1. Pickup and place a button into the cover
2. Assembly the cover to the base and snap-on.

The following steps were taken to make these changes:

1. Made engineering drawings for new cover and base.

The conclusion was to retain the cover because its function was basic. There was no need to retain the pinned cover. The next step was to brainstorm ways of securing the cover to the base without pins. We considered nonmetallic pins, glue, and ultrasonic welding. Finally, the solution was lock tabs that were part of the cover and that would mate with a window in the base, thereby securing the cover to the base (Figure 3).
2. Requested quotes on new mold tools and modification to an existing mold, to accommodate the new design and increase capacity, thereby affording the opportunity to compete for new business. Tooling quotes were:
   a. Revamp existing 4-cavity cover mold $ 6,000
   b. Build new 6-cavity cover mold $10,000
   c. Build new 4 cavity shuttle mold for base $28,000
   Total capital expenditure $44,000

3. An ROI computation (Table IV), was prepared showing the investment was worthwhile. It would have been even better if the semiautomatic operation had not already been implemented thereby affecting the potential cost savings. However, the gross profit margin for the next year would be increased from 26 to 47 percent.

4. To have another measuring device to lend credence to the idea, a break-even analysis was prepared for the management.

Table IV. ROI Computation

<table>
<thead>
<tr>
<th>Profit</th>
<th>Sales</th>
<th>= ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>$52K</td>
<td>$457.6K</td>
<td>1.18</td>
</tr>
</tbody>
</table>

Break-Even

The analysis in Figure 4 shows the break-even point and profit of the new snap-on concept. Break-even was calculated using the formulas given in Table V.

Table V. Break-even Formulas

<table>
<thead>
<tr>
<th>Total factory cost:</th>
<th>TC = F + Q*V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Break-even dollars:</td>
<td>S* = PQ*</td>
</tr>
<tr>
<td>Break-even quantity in units:</td>
<td>Q* = F/P-V</td>
</tr>
</tbody>
</table>

| Total sales: | S = PQ |
| New profit:  | NP = S-TC |

The change in cover and base designs allowed the company to maintain the same sales price for 3 years and increase the gross profit, even though labor and material costs increased.

Conclusion

The lesson to be learned in this example is that any company should do preliminary work and background studies before entering into an automation project. This helps ensure that priorities are in their proper order. Automation could become a second or third step in ensuring the best course of action.

Remember that value is multi-dimensional. Why hang a $25 picture with a $50 gold-plated spike. You could use a 5-cent galvanized nail!

The VE job plan should be followed before making changes that have an impact on capital. The original investment of $88,800 was unnecessary and this would have been recognized if the job plan had been used.
RE & VE Partners in Competition

BY Mark G. Matonek

Mr. Mark G. Matonek, is the VE Program Manager (VEPM) for the Belvoir Research, Development and Engineering Center, Ft. Belvoir, VA. He has a BS in engineering from Western Michigan University, in Kalamazoo, MI, and a MS from Shippensburg State University, Shippensburg, PA. He began his career in VE in 1982 as VEPM at Ft. Ritchie, MD. He is an Army-accredited instructor for the Principal and Applications of VE course, and an active National Capital Chapter member. He has held positions in the government; Treasury Dept., DoD, and worked in private industry for GM.

Introduction

Reverse Engineering (RE) and Value Engineering (VE) are two programs that over the past few years have been receiving increased attention. Both programs are integral parts of Congress's and the Department of Defense's (DoD) quest for increased competition to reduce the cost of spare parts. The hysteria caused by the "horror stories" of outlandish prices paid for spare parts, e.g. $500 hammers, $1500 alien wrenches, etc., prompted Congress to initiate laws and regulations to alleviate the problem.

DoD Development

DoD's thrust for increased competition was led by Defense Secretary Caspar Weinberger's memorandum in July 1983 announcing a ten point program on spare parts procurement. In a follow-up memo, August 1983, policy revisions to the DoD spare parts acquisition process were outlined that included the use of VE to identify unnecessary costs, and the immediate implementation of the Defense Acquisition Regulation Supplement No. 6, entitled, "DoD Replenishment Parts Breakout Program."

Background

The Competition in Contracting Act of 1984 and subsequent legislation (i.e. Public Laws 98-525 and 577) have introduced sweeping reforms in the way competition is handled throughout the government acquisition community. The intent of these laws has been to make competition the norm instead of the exception. Specific defense procurement policies have been established requiring DoD to require property and services in the most timely, economic, and efficient manner. "Full and open competition" have become the latest buzz words, and they are affecting just about everyone in government today.

Value Engineering

The concept of finding lower cost substitutes to perform the function of original equipment, while maintaining safety, quality and reliability is now being applied to the competitive procurement of spare parts. Just the mention of VE by the Secretary of Defense has given VE and the VE community a tremendous boost. Today, VE maintains high visibility and is no longer treated as just another cost reduction program. Resources have been allocated by the various DoD services, and contractors are continuously being urged to investigate the benefits of VE within their contracts. In an article on VE in the Nov./Dec. 1987 issue of Government Executive, statistics from the Office of Federal Procurement Policy (Figure 1) show that DoD in fiscal 1986, invested over $100 million and recorded savings totaling $2.5 billion, an impressive 25 to 1 return on investment from VE. That same year, even greater returns were reported by other civil agencies.

The cliche "when it rains it pours" may very well be applicable to the future success of VE. In fact, the Office of Management and Budget has issued Circular
Value Engineering Savings for Fiscal Year 1986

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<tr>
<th></th>
<th>Invested</th>
<th>Saved</th>
<th>Return on Investment</th>
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</thead>
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<td>50:1</td>
</tr>
<tr>
<td>Air Force</td>
<td>$39 million</td>
<td>$608 million</td>
<td>16:1</td>
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<td>Navy</td>
<td>$54 million</td>
<td>$556 million</td>
<td>10:1</td>
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<td>$701,000</td>
<td>$60 million</td>
<td>86:1</td>
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<tr>
<td>Energy</td>
<td>$152,000</td>
<td>$15.8 million</td>
<td>104:1</td>
</tr>
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<td>Veterans</td>
<td>$188,000</td>
<td>$8 million</td>
<td>38:1</td>
</tr>
<tr>
<td>Interior</td>
<td>$100,000</td>
<td>$5 million</td>
<td>50:1</td>
</tr>
<tr>
<td>GSA</td>
<td>$55,000</td>
<td>$2.3 million*</td>
<td>42:1</td>
</tr>
</tbody>
</table>

*based on 5-year average
Source: Office of Federal Procurement Policy

Figure 1

Today, VE maintains high visibility and is no longer treated as just another cost reduction program.

No. A-131, Value Engineering, to the Heads of Executive Departments and Establishments requiring them to use VE to identify and reduce costs. It requires agency heads to establish and improve their use of VE programs.

Reverse Engineering

As for RE, its influence on competition can be traced to the DoD Replenishment Parts Breakout Program. This program has a major objective of "breaking out" spare part purchases from prime contractors and buying directly from the actual manufacturers, and ultimately from anyone, thru competition. However, the competitive reproduction of spare parts is dependent upon the availability of data rights and adequate technical data. Guidance outlined in the Breakout Program recognizes this problem, and as part of full screening, KE may be employed for obtaining or developing necessary data for a competitive procurement Technical Data Package (TDP).

RE is the process whereby drawings and specifications are made as a result of measuring physically examining and measuring existing parts to produce technical data with unlimited rights. RE is essentially the process of copying a part. It is an excellent tool for developing a competitive TDP, however, the application is not automatic and should be used only if other means are not possible or feasible. It should be used as a last resort.

Within the government there are several conditions that must be met before RE can be employed. First, the government has technical data but it is inadequate because a complete technical data package was never bought, or they feel the price is excessive. Secondly, the government's data is marked "proprietary" because they feel it's too expensive to buy the rights to the data, or dialogue with the data source has been unsuccessful in reaching a negotiated position acceptable to both parties. Finally, the government may have a situation where their Industrial base has dwindled and they simply don't have a source for the part or for engineering data defining the part. When these conditions exist, the government looks to RE as the tool for developing the engineering data necessary to assemble a competitive TDP.

It's Legal

It is important to add that RE is a lawful means of discovery for items in the public domain provided the government follows some basic rules. The government must ensure that proprietary data is adequately protected. That is, during the RE process, the government must ensure that the RE contractor personnel have no access to such data, that the RE contractor does not employ any recent employees of the manufacturer involved, and that no visits are conducted to the proprietary manufacturer's plant by any RE, contractor or government personnel involved. The government must also be careful not to initiate RE of an item if a specific contract clause is in effect that would prohibit such action.

Reverse Engineering Pilot Program

To support the Breakout process, Congress, in a report relating to the DoD Appropriations Bill for 1985, directed each Service to conduct a pilot RE program. The program was initially to run for 18 months, each service allocating $5-million and Defense Logistics Agency (DLA) $200,000. Congress expanded the pilot program in late 1986 ($10 million for the services and $400,000 for DLA) and extended the program until April 1988, a total of 36 months.

The U.S. Army's RE Pilot Program was assigned to the U.S. Army Materiel Command (AMC) who, in turn selected the U.S. Army Troop Support Command and Belvoir Research Development & Engineering
Center to lead the effort. Belvoir RD&E Center was selected because it had a contractual instrument in place which allowed for an expeditious task initiation. The basic thrust of the Pilot Program was to allocate $10 million dollars, to RE a selected number of spare parts, to document lessons learned, to develop a "How To Manual," and to evaluate and report on program effectiveness. The final report on the Army's Program is due 22 April 88.

The Army's Pilot Program consisted of two phases. Phase 1, called Vanguard, involved an engineering services contract that included a task to RE TROSCOM items and selected spare parts from the other AMC major subordinate commodity (MSC) commands. This phase ended 1 October 86, and was immediately followed by a second "Blossom" phase which involved all MSCs developing individual programs that would run to the end of the pilot program.

Overall results and status of the Army's Program are summarized in figure 2. In the Vanguard Phase, $1 million was obligated which resulted in 16 parts being completely reverse engineered. Competitive TDPs have been developed and are available for procurement action. Based on previous prices paid, $9.5 million in life-cycle savings have been estimated. Additionally, an excellent "How To" manual: "US Army Reverse Engineering Handbook (Guidelines and Procedures)," MIL-HDBK-115 has been developed and made available through the Naval Publications and Forms Center for DoD-wide use. The follow-on Blossom Phase is well along with significantly greater savings being anticipated and a fully institutionalized program in place by May 1988.

**Army Pilot Program Status**

<table>
<thead>
<tr>
<th>Vanguard</th>
<th>$1M TROSCOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 Parts Complete</td>
<td>TDPS's Available, Solicitations in Process</td>
</tr>
<tr>
<td>$9.5 Million Est. Savings</td>
<td>+ &quot;How To&quot; Manual</td>
</tr>
</tbody>
</table>

**Blossom**

<table>
<thead>
<tr>
<th>$9M All MSC's</th>
<th>150 Candidates Working</th>
</tr>
</thead>
<tbody>
<tr>
<td>$SAVINGS</td>
<td>INSTITUTIONALIZED ARMY PROGRAM 1 MAY 88</td>
</tr>
</tbody>
</table>

**RE/VE Connection**

To date the Army's RE Pilot Program has shown significant and impressive results. Lessons have been learned that will benefit everyone. Of particular interest is the role VE has played in the RE process. Early in the RE the concern for VE implications of RE candidates was critical in revealing cost drivers beyond the sole source restrictions. It made little sense to replicate a part with excessive material requirements, tolerance restrictions, design defects, or excessive performance requirements. Why copy a defective or a "gold plated" part. An example from the Pilot Program was the roof lifting and roof leveling jacks (Figures 3 & 4). VE was used in the RE on these two items to improve upon design defects which would have resulted in the replication of defective and unacceptable parts. Resultant drawings on these items included VE improvements.

For 30 years, this weapon against government waste has languished. Soon, government agencies may have no choice but to use it.

The concern for VE reviews on future RE candidates has not been ignored. In fact, outlined within the US Army Reverse Engineering Handbook, a section (4.3.2) is included to insure that VE studies are considered before the completion of the RE process.

**Roof Lifting Jack**

**Price Reduction Through Competition**

| ORIGINAL UNIT COST  | $504.00 |
| UNIT COST AFTER RE  | $139.00 |
| LIFE CYCLE SAVINGS  | $1,527,705 |

**Figure 3**

**Levelling Jack**

**Price Reduction Through Competition**

| ORIGINAL UNIT COST  | $265.00 |
| UNIT COST AFTER RE  | $105.00 |
| LIFE CYCLE SAVINGS  | $301,120 |

**Figure 4**

**Conclusion**

Congress and DoD have recognized the importance of RE and VE within the competition arena. Results to date from the Army's RE Program indicate that RE is an excellent tool for obtaining competitive technical data. VE, on the other hand, has always been a dynamic program within the Army and appears to be headed for implementation within all government agencies. Both programs are powerful partners for increasing competition and ensuring fair and reasonable prices for spare parts. They are two programs that will be receiving even greater attention in the future.

value World, July/Aug./Sept., 1988 21
The workshop program was developed using the standard SAVE 40 hour workshop.

VE skills, present an overview of AVSCOM VE program, assist in the workshops, encourage team members, and visit with management officials to enlist their support.

After the third workshop, Mr. Arnold became more involved in planning before the prep meeting. Before the prep meeting, discussion with management aided in selection of projects and matching team membership with the projects. In that way, prep meetings were conducted with team members as well as management. This preparation was necessary since there were no plans for a meeting before the prep meeting.

As the program progressed, two more companies cancelled and several switched (due to conflict with other priorities). One company canceled (after the prep meeting) since the company determined that it was too small to release 20 people. Another company filled that void.

The second company to cancel was the result of their management questioning the desire to be a host. That company decided that it was a bad investment. At short notice, I contracted TACOM for a substitute and within the allotted time a substitute was provided. The remaining workshops were completed as planned.

At the conclusion of the workshop, each participant was asked to rate the several phases and benefits of the workshop. The average rating of the VE workshop (by the participants of 8 of 10 companies) was 3.99 on the basis of 5. This rating can be considered as very good. Although the rating was meant to determine the
effectiveness of the contractor, it also reflected the participants' evaluation of their own company's plans for project follow-up. Table 1 reflects those ratings.

At the conclusion of the workshop, each participant was asked to rate the several phases and benefits of the workshop.

There was a potential VECP savings of $26.5M for all the projects. Although all the projects were not directly a potential savings for AVSCOM, benefit accrued to other Material Service Commands (MSC)\(^s\) (e.g. TACOM, PM TRADE, etc) as well as other services (e.g. Navy). The potential VECP savings per workshop varied from $0.3M to $9.0M. The average potential VECP savings was $2.65 million per workshop and $5.53 million per project. Since the average cost per project for conducting the workshop was about $20,000 including AVSCOM, contract and company labor and overhead cost, the potential return-on-investment (ROI) was quite high. However, for that workshop in which the total potential savings was only $300,000 the minimum ROI was about 3.3:1. The maximum ROI for the remaining workshops was about 30:1. Table 2 summarizes the activities & results of the 10 workshops.

In retrospect, we did many good things:

a. Early canvassing for participating companies was beneficial. It appears that about 50% of the companies will decline when dates are firmed up.

b. The prep meeting was very beneficial in planning a workshop. This planning was easy for the first two companies since both had active VE departments and had been through many workshops. Both were well prepared at the time of the prep meetings and had picked all projects and over 50% of the membership of each team. The next company was not prepared (no projects or teams had been established before the meeting). The prep meeting ended being one in which the company's management was told why Value Analysis Inc was involved and then explained what happens in a workshop. After that lesson, more preliminary planning was accomplished by telephoning including suggestions of: savings potential for the project, establishing teams and projects before the prep meeting and having split prep meetings with management and teams. Two meetings were scheduled during the prep meeting (e.g. 45 to 60 minutes overview with management and team and 45 to 60 minutes of detailed discussion with the teams, flowing into a team workshop on problem identification). In this manner, the teams gathered information before the start of workshop.

c. The VE techniques and the presentation approach (used by Value Analysis, Inc staff) was conducive to learning and to motivation for workshop participation. The mixture of lecture, films, slides presentations and workshop was about right for completion of the preliminary evaluation of the projects and several alternatives. The presentation by the Value Analysis, Inc staff demonstrated their enthusiasm of their subject. This enthusiasm was transferred to the participants. The presenters and their methodologies make a workshop what it is. The selection of presenter should be weighted toward (a) knowledge of subject, (b) experience, (c) method of presentation, and (d) use of presentation aid and examples.

d. Rating the workshop provides the feedback to the contractor as well as rating his performance. It was a valuable tool.

e. Vendors were allowed to visit teams on the fourth day. Vendors were selected based on alternatives.

Things we didn't do which would have helped further.

The selection of presenter should be weighted toward (a) knowledge of subject, (b) experience, (c) method of presentation, and (d) use of presentation aid and examples.

1. Set up an upper management team within AVSCOM to monitor progress. This should increase company management endorsement.

2. Contract should have included follow up by Value Analysis, Inc. With manpower shortages, VE staff doesn't have time for the required follow up.

3. Planning time before the prep meeting should be increased.

4. Workshop cost was approximately $20,000 per project. Based on minimum of 10:1 return, a project should save approximately $200,000 (preliminary estimate).

5. Workshop should be broken into two segments (Approximately 20 hours each) with two weeks in between. This allows teams to perform necessary detailed evaluation.

6. Management has to show support (e.g. what is expected of team members, allow time to do assignments, etc).

7. Vendors should play a larger part in alternatives.

8. These trained teams should then be used to initiate other teams.
Table 1.
Value Engineering workshop evaluation summary.

<table>
<thead>
<tr>
<th>Rating Category</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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</table>

Rating Values: 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Satisfactory, 1 = Unsatisfactory
Notes: Rating form not used at Company B. Different type ratings made at Company E (their own).

Table 2.
Summary of AVSCOM/Martin Marietta Energy System contracted value engineering workshop.

<table>
<thead>
<tr>
<th>Company</th>
<th>Number of projects/team</th>
<th>Participants</th>
<th>Potential WEC savings</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>25</td>
<td>$3.5 million</td>
<td>Well planned workshop. Good selection of projects. Management behind value engineering program.</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>30</td>
<td>$3.0 million/yr</td>
<td>Very successful workshop with good selection of projects.</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>17</td>
<td>$0.3 million</td>
<td>Projects had low cost saving potential but savings were about 35%. Mechanics of workshop were well planned. Lacked management involvement.</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>30</td>
<td>$3.0 million</td>
<td>Well planned workshop by with good selection of projects. Management behind value engineering program.</td>
</tr>
<tr>
<td>E</td>
<td>5</td>
<td>19</td>
<td>$3.0 million</td>
<td>Good selection of projects. Management involved and interested in workshop.</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
<td>26</td>
<td>$1.2 million</td>
<td>Only two projects had large immediate potential—others depended on future requirements and parts use.</td>
</tr>
<tr>
<td>G</td>
<td>4</td>
<td>22</td>
<td>$1.5 million</td>
<td>Well planned workshop. Best preliminary planning for prep meeting and use of vendors.</td>
</tr>
<tr>
<td>H</td>
<td>5</td>
<td>23</td>
<td>$0.3 million</td>
<td>Includes one Navy team of five, and AVSCOM team of three was also present. (Not counted with projects or participants). Except for one project showing $300,000 savings, projects needed additional study to project results.</td>
</tr>
<tr>
<td>I</td>
<td>5</td>
<td>25</td>
<td>$2.7 million</td>
<td>Substitute workshop for TACOM. Workshop results justified the substitution in terms of benefit to U.S. AMC and TACOM.</td>
</tr>
<tr>
<td>J</td>
<td>4</td>
<td>18</td>
<td>$0.5 million</td>
<td>Some projects are only speculative. Allied-Bendix would have to pursue and win contracts in order to realize gains.</td>
</tr>
</tbody>
</table>

$0.5 million/yr; $3.0 million/yr; $0.3 million; $3.5 million; $3.0 million; $2.7 million; $0.5 million/yr.
Probability and Statistics for Value Engineers — Regression and Correlation

By Jack V. Michaels, PE, CVS

Mr. Jack V. Michaels, PE, CVS, is Consultant to the Director of VE at Martin Marietta in Orlando, Florida. He is the Assistant Editor of Value World and faculty member of Florida Southern College.

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Introduction

Much effort in VE is devoted to projecting budgets and costs, and it is appropriate that VE practitioners gain facility in regression and correlation analysis. Regression is used to determine the probable form of the relationships among variables. Correlation provides the quantitative means for measuring the strength of these relationships.

The work is usually limited to linear regression of two variables; the independent and the dependent variable. The upper-case X and Y are used to denote the independent and dependent variables, whereas the lower-case x and y are used to denote specific values of the variables. The notations x_i and y_i signify the i-th values of the variables.

Linear Regression

Two variables X and Y are linearly related if their relationship is described by:

\[ Y = \alpha + \beta X + e \]

where the parameters \( \alpha \) and \( \beta \) are called the "regression constant" and "regression coefficient." The parameter e is called the residual error and represents the deviations of the individual values of Y about the mean of the values of Y.

Least-Squares Method

Linear regression uses the method of least-squares, which is based on the following postulate: The sum of the squared deviations of observed values of \( y_i \) from the least-squares line derived from \( y_i = \alpha + \beta x_i \) is smaller than the sum of the squared deviations of the observed values of \( y_i \) from any other straight line that can be drawn through the observed values of \( y_i \).

The linear regression model is thus a straight line that is given by:

\[ y_i = \alpha + \beta x_i \]

The values of \( \alpha \) and \( \beta \) for any given set of X and Y data can be obtained by the simultaneous solution of the following normal equations:

\[ \begin{align*}
\Sigma x_i &= n \alpha + \beta \Sigma x_i \\
\Sigma y_i &= n \alpha + \beta \Sigma x_i \end{align*} \]

where \( n \) is the number of data points in the set.

Worksheet

Table 1 is an example of the worksheet used for calculating the regression of Y on X, where again X is the independent variable and Y is the dependent variable. Reversing the role of X and Y would alter the preceding equations.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>x^2</th>
<th>y^2</th>
<th>y_i</th>
<th>x_i</th>
<th>x_i^2</th>
<th>y_i x_i</th>
<th>y_i x_i^2</th>
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<td></td>
</tr>
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<td>6.25</td>
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<td>13.0</td>
<td>9.0</td>
<td>169.0</td>
<td>39.0</td>
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<td></td>
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</tr>
<tr>
<td>3.5</td>
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<td>121.0</td>
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<td>49.0</td>
<td>42.0</td>
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<td>ΣS: 37.5</td>
<td>161.25</td>
<td>109.0</td>
<td>1250.0</td>
<td>376.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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The \( x_i \) values in the table are thousands of operations of a specific process in a production line. The \( y_i \) values are per-unit operation times in seconds and were observed in a methods-time-motion (MTM) study.

The first step in the procedure is to plot the scatter diagram shown in Figure 1. This allows the analyst to judge the suitability of first-order (linear) versus higher-order curves for fitting the relationship between the independent and dependent variables. The illustration shows that a linear (straight line) fit may be suitable.

### Values from Table 1 and \( n = 10 \) are substituted in Equations 3 and 4 to obtain the following normal equations:

\[
\begin{align*}
(5) & \quad 109.0 = 10a + 837.5 \\
(6) & \quad 376.5 = 37.5a + 816.25
\end{align*}
\]

Equations 5 and 6 are solved simultaneously yielding \( a = 16.7636 \) and \( b = -1.5636 \), which when substituted in Equation 2, yield:

\[
\begin{align*}
(7) & \quad y_i = 16.7636 - 1.5636x_i
\end{align*}
\]

Equation 7 gives the regression of \( Y \) on \( X \) for the data in Table 1. It is first solved for \( x_i = 1 \) and, then for \( x_i = 6 \), obtaining \( y_i = 15.2276 \) and \( y_i = 7.382 \). The two sets of coordinates, \((1, 15.2276)\) and \((6, 7.382)\), are located on the scatter diagram and the least squares line is drawn as shown in Figure 2.

The negative slope of the line reflects the minus sign in Equation 7. The relationship depicted for \( X \) and \( Y \) is called "inverse-linear" because increased values of \( X \) results in decreased values of \( Y \) at a constant rate.

### Correlation

The next question is what is the strength of the relationship between the variables \( X \) and \( Y \) as represented by the least-squares line in Figure 2. This answer is provided by the coefficient of determination which is simply the square of the former.

The values of the coefficient of correlation range from -1 to +1. The closer the values are to either of these extremes, the greater the correlation between independent and dependent variables. These relationships are shown in Figure 3. Note that the second-order relationship resembles an exponential curve with a coefficient of correlation close to +1.

The range of values of the coefficient of determination, which is the square of the coefficient of correlation, is 0 to 1. The equation for calculating the coefficient of determination, denoted by \( r^2 \), is:

\[
\begin{align*}
(8) & \quad r^2 = \frac{\sum x_i y_i - (\sum x_i \sum y_i)/n}{\sqrt{\sum x_i^2 - (\sum x_i^2)/n} \cdot \sqrt{\sum y_i^2 - (\sum y_i^2)/n}}
\end{align*}
\]

Substituting the values from Table 1 in Equation 8 yields:

\[
\begin{align*}
(9) & \quad r^2 = \frac{-1.5636 \cdot 161.25 - 37.5 \cdot 125}{125 \cdot 1109.0}\frac{2}{10} = 0.8146
\end{align*}
\]

The value of \( r^2 = 0.8146 \) means that the regression of \( Y \) on \( X \) explains 81.46 percent of the total variability in \( Y \). In other words, 81.46 percent of the variability in \( Y \) is a function of \( X \) and 11.5 percent is due to other causes.

The value of the coefficient of correlation is the square root of 0.8146, or 0.9026. Because of the inverse relationship between \( Y \) and \( X \), as shown in Figure 1, the coefficient of correlation is negative and \( r = -0.9026 \).
Confidence Interval

The next question concerns the confidence interval about the least-squares line as a function of the desired confidence level. The general form of the relationship is shown in Figure 3.

The parameters L_u and L_l denote the upper and lower limits of the confidence interval about the least-squares line for the regression of Y on X. Note that the interval is shortest at the mean of X (X̄) and that the confidence interval grows wider as X moves away from the mean. The limits in the illustration are for a confidence of 95 percent. The spacing between the limits increases with increased values of confidence.

The spacing between the limits increases with increased values of confidence.

Note also the nonlinear (second-order) nature of the curves depicting the confidence limits. The nonlinearity is due to the following second-order relationship used to calculate confidence limits (CL).

\[ CL = y_e \pm s_{y|x} \sqrt{\frac{1}{n} + \frac{(x - x_e)^2}{\sum (x - x_e)^2}} \]

The notations \( y_e \) and \( x_e \) in Equation 10 denote the estimate of Y for a specific value of X. The appearance of the t-statistic in the equation is necessitated by the small sample size. This was discussed in the fifth installment of this series. (Vol II, #1 page 24.)

The value of \( t_{1-\alpha/2} \) is obtained from the table of the Student's t distribution for the given significance level \( \alpha \) and degrees of freedom (DF) which are given by n-1. For a confidence of 95 percent or 0.95, \( \alpha = 1 - 0.95 = 0.05 \), \( \alpha/2 = 0.025 \), and 1 - \( \alpha/2 = 0.975 \). The table would be entered in the 0.975 column and the row for DF = 10 or 9, yielding the value of 2.262 for the t-statistic.

The notation \( s_{y|x} \) in Equation 10 is called the unbiased estimate of the population standard deviation of Y given the standard deviation of X, and can be calculated with:

\[ s_{y|x} = \sqrt{\sum (y - y_e)^2 / (n - 2)} \]

The symbol \( \bar{X} \) is the sample mean of the variable X and is given by:

\[ X = \frac{\sum X}{n} \]

For the data in Table 1, \( \bar{X} = 37.5/10 \) or 3.75.

Predictions

Regression and correlation are important tools for predicting future events from historical data. For example, an application could be to predict on the basis of the data in Table 1, the per-unit operation time when 70,000 operations are performed.

Regression and correlation are important tools for predicting future events from historical data.

First, \( y_e \) is calculated using Equation 7.

\[ y_e = 16.7636 - 1.5636(7) \]

\[ = 5.8184 \text{ seconds} \]

Next, \( s_{y|x} \) is calculated using Equation 11.

\[ s_{y|x} = \sqrt{\frac{(250.0 - 16.7636)^2 + (109.0 - 1.5636)^2 + (376.5 - 1.5636)^2}{10}} \]

\[ = 1.1970 \]

Finally, the following variant of Equation 10 is used to calculate the 95-percent confidence limits for \( y_e = 5.8184 \) seconds.

\[ L = y_e - \frac{t_{1-\alpha/2}s_{y|x}}{\sqrt{n}} \]

\[ L = 5.8184 \pm 0.3978(1.1970)/\sqrt{10} \]

\[ = 5.8184 \pm 0.5875 \text{ seconds} \]

Thus it can be predicted with 95-percent confidence that when 70,000 operations are performed, the per-unit operation time will fall between 5.2309 seconds and 6.4059 seconds.

Summary

This final installment in the current series presented regression and correlation as useful tools for the VE practitioner. A future series of articles will be devoted to applications that were the subject of numerous inquiries regarding the previous six installments.

Author's Note

This is the seventh and final installment on aspects of probability and statistics that are important to the practice of VE. This installment is adapted from the book, Design to Cost, by Jack V. Michaels and William P. Wood. To be published by John Wiley & Sons, Inc., in 1989. Readers may continue to address inquiries to me at Martin Marietta Corporation, Mail Point 275, Post Office Box 5837, Orlando, Florida 32855.

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Get Honest with Vendors

by Thomas R. King, CVS

Key to cost savings ideas from vendors lies in effective communications. What the producer does not know or see about the consumer's needs, limits the areas in which he can help with cost savings tips. This issue burns both ways. A buyer's blind spot of the vendor's high cost areas will prevent dialogue from focusing on potential product feature tradeoffs.

Much unnecessary product cost exists today because of a lack of candor between producer and consumer.

An equally contributing factor to unnecessary cost is the bestowed value syndrome. That is, the assumed cost benefit worth of product features to customers as perceived by the producer without inquiry. In other words — biased projection.

Assumptions are made without facts. Producers in their zeal to convince consumers of significant product features often delude themselves that the customer feels the same. Questions aren't asked.

Case in point: a track mounted drill manufacturer was experiencing a declining market share for its product, prompting a study. An analysis by engineering and sales determined that the market loss was being absorbed by a new product entry: embarrassingly, an inferior competitive design but at a substantially lower cost. The inferiority being that the competitive product could only drill at right angles. Meanwhile, the forsaken unit could drill at obtuse and acute angles, up in front of the machine and down in back — every which way.

So, "go sell" said the manager. This was communicated to prospective buyers with an almost universal reaction. "Sir, all we care about is poking a hole, and this present unit does it just fine."

Prior to this, no one had ever asked the user what the specific features were worth to him personally. An assumption was made. Buyers likewise often hesitate to question product design as there is a general notion that features get a free ride as a part of the total package. Or just as bad — they are necessary otherwise they wouldn't be there. Being there is one thing: being cost justified is entirely another matter.

There is a certain mystique and truth about the statement that one does not miss what one has never had. Aristotle put it succinctly many years ago: no one regrets the lack of a third eye. But the converse of that is also true: people grudgingly give up existing features unless the tradeoff represents a fair compensation. An effective way to evaluate this is by putting a cost on function and assigning a relative value of worth. How much are you willing to pay for that function? If cost exceeds worth, then appropriate action is needed.

Vendor involvement has not gone far enough. Asking a vendor for a cost improvement idea is commendable, but hardly sufficient. A vendor's contribution can be so much more meaningful through the use of value techniques.

There is a vital difference between routine cost improvement (individual ideas) and full scale VE programs. And the difference as I see it is — function. Buyers should be buying FUNCTIONS — not ITEMS.

That is, we should not be buying bolts and nuts rather, we should be buying holding power.

We should not be buying motors — rather, torque and horsepower.

We should not be buying tires — rather, mileage, safety and comfort.

And we should be thinking about value. Value is determined by the lowest cost to provide the required function or service at the needed time, place and with the essential quality. For the supplier, value means providing no less than that. For the buyer, it means paying for nothing more.
PUBLICATIONS

"The Contractual Aspects of Value Engineering" has been published by Dr. William Copperman and North Carolina State University.

This contractual aspects course consists of 4 video cassettes, each approximately 45 minutes. The study guide, "Contractual Aspects of Value Engineering," is integrated into and parallels the video lessons. The last videocassette is a question and answer session between J. Jerry Kaufman and William H. Copperman. The course focuses on the standard paragraphs of a value engineering clause.

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Purchase Price: $2000

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STUDY GUIDE

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One videocassette and a copy of the study guide for one week preview is $120. Of the preview fee, $75 is applicable to rental or purchase.

"Value: The Success Criterion" is available through SAVE for the cost of duplication and handling, thanks to the generous assistance of Westinghouse Electric Corporation.

COST
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3/4" $30.00 each

"Value Engineering - A course for Education & Professional Development" by J. J. Kaufman. This Value Engineering short course consists of 14 videocassette lessons, each approximately 45-55 minutes. The comprehensive study guide, "Value Engineering for the Practitioner," is integrated into and parallels the video lessons.

COST
Rental Fee: $1400
Purchase Price: $5600

Videocassettes are offered in standard formats of 3/4" U-Matic or 1/2" VHS.

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