An Architect Looks at Value Engineering
(see page 2)
PUBLICATIONS

BOOKS:

"Techniques of VA & VE (3rd Edition)" by L.D. Miles. This book, authored by the originator of Value Analysis and Engineering Technology, shows management and professional people specific steps to disciplined thinking, giving them 25-50 percent more efficiency—both in the quality and quantity of their mental work.

COST  Non-Member $36.00  Member $32.00

"Innovative Change, 101 Case Histories Value Engineering" by A.E. Mudge. This book presents step-by-step techniques and procedures; the first part discusses the theory and fundamentals of the crucial ingredients of program management, the second part details the application of the theory and fundamentals to a program, and the third part provides meaningful supporting data.

COST  Non-Member $37.00  Member $33.00

"Value Control Design Guide" by Value Analysis, Inc. This 400 page "Guide" classifies and compares 60 different manufacturing processes used to produce individual parts made from either metallic or plastic materials. In addition to general design information and a detailed explanation of each process, there is a relative cost comparison for producing any quantity of parts, as well as tooling, labor and material waste cost comparisons.

COST  Non-Member $110.00  Member $90.00

VIDEOTAPES

"Principles of Value Analysis/Value Engineering" The Miles Value Foundation, in cooperation with the Society of American Value Engineers and North Carolina State University, produced this 35 minute presentation to introduce you to the concepts and benefits of Value Analysis.

COST  Non-Member $195.00  Member $145.00


COST  Non-Member or Member $40.00

"Keeping the Competitive Edge with Value Analysis" by Robert Brethen, President and Chief Executive Officer, Philips Industries, Inc. Mr. Brethen tells an exciting story about how his company has applied the tools of VA to achieve dramatic results in product enhancement, market share growth, cost reduction, and profit improvement. Philips Industries received the society's highest award—Excellence in Value Engineering for 1988.

COST  Non-Member or Member $20.00

"Manufacturing: A Competitive Weapon" by Al Mattaliano, Staff Vice President, Manufacturing, Hughes Aircraft Company. Mr. Mattaliano describes a revolution in manufacturing technology that is occurring at Hughes. The concepts and practices of just-in-time, expert systems, cycle time management, automated work instruction, flexible manufacturing, and computer aided design and manufacturing, integration are illustrated through example from the several manufacturing plants. The role of VE in this environment is identified.

COST  Non-Member or Member $20.00

All the above orders must be prepaid. Send orders to:  SAVE NBO, 60 Revere Drive Northbrook, IL 60062

ORDER FORM ON BACK COVER
Contents

An Architect Looks at Value Engineering (or)
The View from the Bottom
2
by John D. Sankey

On Written Communication
7
by O. James Vogl, CVS

Value Engineering and Ergonomics at Olin-LCAAP
9
by William L. Czeschin

Dare We Think Differently
12
by Luis M. Venegas, PE, CVS

Computer-Aided Project Management Tools
18
by Gamil B. Girgis, Ph.D., PE, CVS

Value Analysis for Business Development Planning
21
by Martin N. Fabrick, CVS & Joseph O'Roarke, PE, CVS

Risk Management for Value Practitioners
25
by Jack V. Michaels, Ph.D., PE, CVS

EDITORIAL POLICY: To provide informative, timely
and interesting communications pertaining to Value Engineering / Value
Analysis and related disciplines. VALUE WORLD enables contributors
to express themselves professionally in advancing the art. VALUE
WORLD is dedicated to the establishment of a mutual bond among
those seeking to better the quality of working life and establish a
communications network through which participants can interact for
mutual benefit.

The views expressed in VALUE WORLD are neither approved or
disapproved by the Society. They are the expressions of the author(s).

All papers have been edited — frequently condensed — by the editor.
An Architect Looks at Value Engineering (or) The View from the Bottom

by John D. Sankey

John D. Sankey, PA, PE, Project Architect, Corps of Engineers, Design Branch, Kansas City District


Introduction and Disclaimer

This paper is based upon the experience and views of one government employee. I have been engaged in the design of construction projects for some time in both the public and the private sector. During the past five years I have been a project architect in the design branch of the Kansas City District, Corps of Engineers. During this time, I have been a part of VE studies, conducted both on my design, and also on the design of others. This paper is based upon those experiences.

Your Project is Going to be Value Engineered

Those words can generate a great deal of emotion in the heart of a project designer, most of it negative. To the designer it means that some, as yet unknown, person is going to second guess your decisions. This person knows nothing about the project. This person knows nothing about the needs of the user. This person will not appreciate the uncountable hours of sweat that you have put into this design, to finally make all of the pieces fit, in just the right way. This person is trained to find the hidden flaw. This person will take the offense, you will be on the defense. This person is interested primarily in the bottom line, money. This person is a professional hacker bureaucrat, licensed by the highest authority to make mischief. This person has the benefit of 20/20 hindsight. This person will be right, and you (along with Charlie Brown) will be the goat.

To design something is to create something, and creation is a very personal thing. Everyone that is part of the design process becomes emotionally involved to some extent or the other. Besides the principal designers (those who get paid to design things as a primary job responsibility), there are the other designers (the users, the facility managers, the post/base planners) who also are involved, and emotionally connected with the design. To all of these participants, the design, as it stands, is the design they want to keep; because it is the design that they, together, created.

With the warning of the impending attack, launched by the office of VE, the defenders prepare themselves. The value engineers that I have worked with, seem to appreciate, and anticipate, this designer ownership and defensiveness. Regardless of any negative emotion being experienced by the project designers, cooperation from the project designers must be achieved for any meaningful VE to take place.

In the VE studies that I have been a part of, the VE professionals focused on organizational objectives, and not on personalities. In one study that I remember, the first goal set down by the VE team was to make sure the designers and the user client did not look bad. The real focus, after all, is the good of the project; and not the punishment of the designers. Once the participants understand that the design will be analyzed in an objective non-personal manner, barriers begin to come down. There are many ways to present the findings of a VE study. I have never seen a VE team intentionally try to make anyone look bad. On the contrary, I have seen VE teams put forth a conscious effort to avoid finger pointing.

If the focus of the VE study is not to place responsibility, then how do the results of the study get built into future projects? If we don't make the designers accountable with finger pointing, then how do we learn?

The designers, are far harder on themselves than any outside force can hope to be. No designer intends to be any less than good at whatever they do. No one starts a project and says; I am going to put problems in this design, or I am going to go over budget, or I am going to leave a necessary something out. During
the VE study, a great number of things get second guessed, taken apart, rearranged, and then put back together again. When a good idea is uncovered, it becomes apparent to the entire VE team, designers included. Usually the designer is sitting there, kicking himself, thinking, why didn't I think of that? A learning process is taking place. If a similar situation arises on a subsequent project, you can bet, that if that designer is involved, it will be handled differently. What I am saying is; that in my opinion, as far as the VE team designers are concerned, things take care of themselves.

The VE study is always a learning experience for everyone on the team. Once the designer understands this, a VE study can become a rather enjoyable time. The VE study provides a way of exposing the designer to new ways of looking at a problem, and new ways of finding solutions. The design team should actually think of VE as a continuation of the design process. If the designers on the VE team are already learning things from the study, that will help make future projects better. What about the majority of designers remaining that are not on the VE team? How do their projects get the benefits?

I am a great believer in communication of all kinds. Half of life is just showing up, being there and being willing. The rest is communication. Here is an idea that I would like to see implemented. I would like to see every VE study written as a one page report, to be distributed to the remainder of the organization. I think that the important points to remember from most VE studies can be described on one page. The report should include the principal ideas developed and the lessons learned. It would be like a book report, or a movie review. The one page report might simply be a copy of the VE abstract. Anyone interested in more detail could pick up the telephone and ask for a copy of the full VE study.

Value Engineering as Part of The Design Process

VE should always be part of the design process anyway. A good designer is continually thinking VE type thoughts all of the time; weighing trade offs, comparing alternatives, studying, consulting with others, etc. All designers should understand, be familiar with, and welcome the VE process. The point being made is that a good designer is going to be doing VE type things as a normal part of the design process anyway. This will be going on regardless of whether there is a VE study scheduled or not.

The benefit/cost ratio of VE ideas is greatest in the earliest stages of the design, and this ratio then decreases exponentially as the design proceeds.

Aside from those VE things that a designer can do individually and independently to further the creative process, and better the design; what ways are available to the organization to promote VE throughout the normal design process that would make the project better? Several ideas come to mind.

1. Send the project designers to VE school. Train them to understand and apply the VE techniques. This might help some, but it probably would not result in a design much different from that originally conceived. Remember, that good designers already are in the habit of thinking like value engineers.

Sending designers to VE school might provide one small benefit however. It might make the designers appreciate more the reasons why the value engineers are "snooping" in their design. It might make the designers less defensive toward VE studies.

2. Assign designers to the projects in pairs. That way they could interact, stimulate each other, and question each other's ideas. I would think that the most design improvement would result if the designers could take certain steps to remain independent of one another. This would force independent thought, at least during some parts of the design. Ideas would naturally be combined from time to time, and eventually collaboration would have to result. Designers working in pairs would improve design, but the added cost to the design budget would, in my estimation, not equal the benefits.

3. Have periodic in-house critiques of selected ongoing projects. I have heard of design offices where this method has been applied to advantage. I have also experienced this technique first hand as an architecture student in college. It works very well as a tool to stretch and expand the designer's point of view and frame of reference. Some designers already solicit input from others, some do very little.

There is no formal mechanism in place to insure that any design represents the best collective effort from the section as a whole. Designs usually represent the best effort of an individual designer. Two heads are better than one (usually), and many heads can be better than two (up to a point).

One way things could work in a design section would be for the section to get together for 15 to 20 minutes and discuss one person's project. It could be over lunch (but this might not work because of individual lunch routines).

The process of presenting, critiquing, evaluating, and defending ideas broadens the designer's base perspective of the problem, and leads in the end to more sophisticated, better thought out solutions. One ground rule that I would suggest is that; the final design decision is to always rest with the individual designer. The purpose of the critique is to uncover different points of view, new ideas, and alternative solutions; to expand the designer's point of view; rather than to force the designer to accept outside direction.

As mentioned before, any real improvement in design becomes obvious to the designer, once the improvement is discovered. Once discovered, if there is real improvement, it is usually incorporated. The problem for most designers is not when to build in more improvements, but the problem is rather when to quit doing the improvements. There is a tendency to want to continue to make things better.

In-house group critiques can help this problem also. The group might notice when a design is bugged
down and is being overworked, with no great amount of gain forthcoming. In addition, occasional get-togethers of participants from other disciplines outside the section can also bring yet more new perspectives to bear on the design.

4. What about dividing the VE study up into several small parts? If a project is worth a certain dollar value, we already know there will be a VE study. We also have a good idea going into a project, that the project is going to exceed the certain dollar value, and will therefore be the subject of a VE study. Given that we know ahead of time that there will be a VE study, we could easily program a VE study into the project schedule from the beginning. Also if we know there will be a study, what is to prevent us from conducting the study in smaller pieces throughout the design?

Could we make the partial VE studies small enough, and discrete enough so that the sum of the partial VE studies would not grow to be larger than the normal single VE study? (a favorite government trick). This might prove difficult to accomplish. If this were to be possible, we would not then be making extra work for ourselves, but we would still be getting an added benefit.

As mentioned before, the benefit/cost ratio of VE ideas is greatest in the earlier stages of the design, and this ratio then decreases exponentially, from there on as the design proceeds. A VE study in parts can take advantage of this fact. Some parts of the VE study would take place during very early design stages.

In addition there are certain strategic points in the design process where certain decisions are most appropriately made. Prior to one of these points, there is not enough information available to make the correct decision.

On the other hand, to wait too much later than the appropriate point means that work will have to be redone. Effort is wasted. In other words, certain decisions need to be studied, and made at certain points; otherwise effort gets wasted. Sometimes, if the designer misses a decision point, the tendency is to just ignore that particular decision, and proceed with the design, while leaving things pretty much as they happen to be at the time. This is assuming that things will work, when left pretty much as they happen to be at the time.

Small VE studies spread throughout the design would improve the chances of hitting the appropriate decision points.

Smaller bites might also be easier to chew (easier to get project designers to find the time to participate). The formal VE process could be spread through more parts of a design, rather than taking place at just one point.

From a VE management point of view, spreading the VE effort throughout the project makes the VE payoff more difficult to measure. The VE idea is no longer the sole property of the VE process alone. As the VE process becomes more and more integrated into the design process, they become one. Who then gets the credit for the VE savings, the value engineer or the designer? This is a problem only because the success of the VE staff is measured by adding up the VE savings they can find. Usually the VE system is based upon design changes and savings accrued to the best and final design. Now, when the design is complete, it will have been already VE'd.

Designer Cooperation Essential

VE cannot function well without the support of the technical project design staff (Design Branch).

The VE staff knows the VE process (the principles, pitfalls, objectives, procedures, methodologies of VE).

The technical design staff (Design Branch) knows the relevant technical disciplines (the principles, pitfalls, objectives, procedures, methodologies of the technical disciplines). Sometimes the technical design staff also knows the details of the project that is to be VE'd. This occurs if it is the same project that the designer has been working on.

Together, the professional VE staff and the technical design staff possess the complete body of knowledge necessary to conduct a good VE study. Without either party, the body of knowledge is incomplete.

It would be inefficient for either party to attempt to learn the skills necessary to function without the other. Limited human capacity is compensated for by specialization of knowledge and experience.

Good VE studies are achieved by assembling good VE teams made up of both good VE professional staff and good technical design professional staff.

The characteristics of a good technical design person for a VE study are:

1. Superior mastery of the individual's area of technical expertise.
2. Above average creative abilities and skills.
3. A genuine desire to improve the project, i.e. can place the good of the project above one's own ego and feelings of project ownership.
4. Above average communication skills (written and oral).
5. The ability to get along with people (political savvy and a cooperative spirit).

The first three characteristics of a good VE designer team member are also those characteristics that make for a good project designer. The last two characteristics are in addition to the characteristics of a good project designer. In other words, a good VE designer team member then is a good project designer with some additional communication and people skills (team player skills) thrown in.

It is important that the organization's management appreciate the linkage between good VE studies and good designers. The same people that the VE office would like to have for the VE study are exactly those same people that the section chief wants to keep back in the section (the best people). If everyone in the section
is busy, the chief would rather do without someone who is not quite so valuable. These are difficult decisions to make.

From the point of view of the design section chief, the more important task is the ongoing work within the section. VE is another secondary task, a task to fit in if possible, a task for those who happen to be available at the time. Normally, the lesser talented or lesser experienced are seen as being available more often.

The organization might want to look at a bigger picture. The Government might be ahead in certain situations if the best designers were sent off to do a VE study, as opposed to sending those we can best do without. If we use our best talent for a VE study, a high priority design deadline most likely will have to be slipped. This assumes that the best talent is already committed to high priority designs. This will cost the Government money. If we use our best talent for a VE study, we might also get a better study. This “might make” the Government some money. Will we make more money than we lose?

The key is to make the decision based on “highest efficiency.” The efficiency of a choice is equal to the product of the expected return times the probability of success. It is not unusual for a VE idea/suggestion/solution to be worth a million dollars. If that idea/suggestion/solution has a high probability for success, then there is a great efficiency associated with finding that idea, etc.

At the same time, what is the efficiency that is lost if the best designer is sent to do the VE study and the high priority project design is allowed to slip? Will the government lose a million dollars if a project gets slipped by one month? It is conceivable that on occasion, it might be more productive to the Government to place a design deadline in jeopardy to maximize a possible return on a VE study. Three weeks of a good designer’s time might be worth more on a VE study than on a design.

These are difficult decisions. Any payoff that might come out of a VE study is usually invisible until the study is about half over. Even payoffs that we think we can see before the study begins can sometimes vanish once the study gets underway. How do you make the “efficient” decision beforehand if you don’t know the expected return?

One thing is certain, to get the cooperation of the design section, the parent organization must allow for the rearrangement of organizational priorities if VE studies are to be given top support. To put it another way; if we (the organization) think that we will gain something by prioritizing a VE Study at the expense of another design project, then we will want the best designers in the VE study. If this is what we want, then we must have the cooperation of the Design Branch, and to get this cooperation we have to give the Design Branch the slack they need to absorb the loss.

Two examples, that I have been associated with, of a good VE effort by a project design team is the UOQ at the Engineer’s School, Ft. Leonard Wood, MO, and the CHEMDEMIL support facilities at Pine Bluff Arsenal, Pine Bluff, Ark.

The UOQ project was memorable in that it was my first experience with VE, and also my first experience with a request for proposal project. When we plugged into the project the A/E had already gone through two complete designs, both way over budget. We took over, as in-house designers, thinking that we were going to do better. The in-house design team also took two shots at the design, and also ended up way over budget both times.

What made everyone especially nervous about this project was the cost and inconvenience the Government was going to have to bear if we didn’t get the project in on time. The new Army Engineering School was being built at Fort Leonard Wood, Missouri. The UOQ was to house the new engineering students who were to attend the new school. If the VOQ quarters were not ready on time, the Army would have to start bussing and housing hundreds of people at distances of up to 20 to 50 miles away, wherever rooms could be purchased. This was going to amount to thousands of dollars a day in lost money.

Someone up the chain of command decided to try to VE the project. Since I was the architect on the job, I was assigned to the VE team. The outcome of the VE study was that it was decided to forget the in-house design idea, and to put the job out as an RFP (request for proposal). It was decided to use industry standard criteria in lieu of our normal Corps of Engineers standard criteria.

The project was a big success. It came in within budget, with full scope, and was finished in time for the first class of students. The original estimate going in to the VE study was $17.5 million. The final cost was $13 million.

The CHEMDEMIL support project was another interesting job. The project was set up to build a plant that would be used to destroy some out-of-date chemical weapons. I thought it interesting that our nation had spent millions to make these weapons, and now we were going to have to spend more millions to build a plant to destroy them.

The working estimate going into the VE study was $13.6 million. The VE estimate of savings was $5.2 million. The savings finally accepted by the user was $3.6 million. Both of these examples represent good, successful VE. In my opinion, the primary reason they were successful is that they both were staffed with a good VE team made up of (1) good, talented value engineering professionals along with (2) good, talented project engineers.

**VE as a Self-Administered Kick in the Rear**

VE can be looked upon as a means whereby the Corps of Engineers can regulate itself. The organization can overcome it’s own nature.

Large organizations develop certain identifiable characteristics. For example: large organizations
develop a bureaucratic structure to manage information flow and people, large organizations are by nature, slow to change, and conservative, large organizations are political. Wherever there are large groups of people joined for a common goal, you will find politics. Large organizations tend to continue in a given direction, doing things today the same way they were done yesterday.

The above traits are neither good nor bad. They are necessary to the structuring and movement of large groups of people toward shared goals. They can on occasion interfere with finding the best solution to a problem. A VE study can act to offset these tendencies where they might interfere.

The VE team looks for a different view of the project. Once a different view is found, a search for a different solution is conducted. If the different solution appears promising to the VE team, a VE proposal is put forth.

Sometimes the VE proposal is viewed with alarm by the parent organization. This can happen for one of several reasons:

1. Fear that the organization will be criticized for not having already found the “different” solution.

2. Fear that the “different” solution is not better, just cheap (inferior quality for cheap price). The project quality will suffer and the organization will get the blame.

3. Fear of the unknown, i.e. unfamiliarity with a different process/product/method utilized in the “different” solution. The unfamiliar might not work, and then the organization will be blamed.

The alarm can translate into resistance by the organization to further develop/accept/use/consider the “different” solution. In many organizations, this alarm initiates the end of the “different” solution and a return to the “original” solution. Because the VE process in the Corps of Engineers is endorsed by higher authority, the leverage is in place to overcome the resistance to further develop/accept/use/consider the “different” solution.

The result is that the VE developed solution can proceed in spite of the fear. The project benefits from a “better” solution. The organization benefits by internalizing a new experience. This beneficial result is brought about by a check and balance built into the organization structure, and it has been built in by the organization itself. That check and balance is the VE process. The organization has devised a way for the organization to be objective about itself (no easy task). In so doing, the organization is able to get outside of itself, and pull itself up by it's own bootstraps. Nice touch!
O. James Vogl, CVS, FSAVE, was commissioned a 2nd Lt. Field Artillery from Purdue in '37. He retired from the Army in '59 and from Hughes Aircraft Co. in '83. He has an MA from the University of California. He teaches Business Communication at UCLA extension Division and in industry. He has been a member of SAVE since 1965 and has held many chapter and national offices in the society. He was awarded the Emeritus and Presidential Citation from SAVE. Jim has been the editor of Value World and SAVE's International Conference Proceedings for the past 10 years.

How often misused words generate misleading thoughts. Herbert Spencer 1820 - 1903

I think all of us in VE will agree that communication is an essential element of our profession. Not only do we need good communication but we must be able to function well with written communication as we know that oral presentations, no matter how effective, must be followed by a written presentation before our ideas will be accepted.

Why then do I encounter such deprecating comments about writing? Why do so many authors make the point that they were not English majors and thus their writing should be excused because of that.

Many of us learned our practical business writing on the job - and modeled our writing on our bosses and the writing that crossed our desks. Since many of us were in a bureaucratic organization, we learned the bureaucratic style - that is at all costs we must never be found at fault. Bureaucratic prose is designed to obfuscate; to fuzz the meaning so that the writer can never be faulted for making a positive statement (that may later prove to be wrong). This evasiveness is an insidious disease that prevents clear communication - and it is absorbed and practiced without examination that reveals its discursiveness.

Here is an example from one of the most high: "To this end, I have directed action to improve the application of all of our material cost reduction policies and techniques."

Mind you, bureaucratic prose is functional for the bureaucrat. It protects him and his associates and no one can accuse him rightfully of committing or omitting anything that might later put him in a bad light. Is it not amazing how any organization can accomplish anything when we never clearly state what is wanted or what is to be done.

Meaningless phrases like "take action" abound. Never in the bureaucratic environment make a definitive statement. Use only the passive voice which never indicates who did what to whom and allows the writer an escape. "It is believed that _____". Who believed? The credibility of the statement depends on the "who." Was it the janitor or the president of the company? We don't know.

Another practice, widely used in business, is the use of deadwood - phrases that add nothing to the meaning but fill space and presumably make sentences sound more important. "Joe Blow is currently the manager of____." "Currently" adds nothing to the meaning - if he is the manager that means now. The currently adds meaning only when the statement is comparing what he is to what he was and even then it is usually unnecessary. "Mr. Brown is actively supporting the___." What does the "actively" add? Can Mr. Brown passively support —?

All these deadwood words hinder understanding for the less words in a sentence the easier it is to understand.

I think our problem is that we don't read what we write. We don't examine our writing to see if all the words are necessary. This is why cliches creep into our writing.

What is wrong with using cliches? The fault is because we can't be sure that our reader has the same
understanding of the cliche as we, the writer, do. Most cliches state the obvious and can be deleted without loss of meaning. Why “few and far between” when just “few” will convey the meaning. Why “part and parcel” when “part” does the trick. Cliches display a lack of consideration of the reader and a laziness of the writer in jotting down the first idea that comes to mind without examining it later to see if that really is the best way to express his idea.

Then there is the unforgivable error of the garbled cliche. The writer thinks he knows the saying but doesn’t and displays his ignorance for all who read his prose. Theodore Bernstein, a former newspaper editor, made a collection of what he called curdled cliches, here are some of them he blue-penciled as editor:

I racked my brains back and forth over that problem.
I don’t know; it’s hydroglyphics to me.
That hits it right on the nutshell.
He needs some money to tidy him over.
It’s a shut-and-dried case.
I was smoking like a chain.
He dashes in and out like a whip of the will.
They’re cutting my throat behind my back.
They’re trying to hurry to get under the gun.
Value Engineering and Ergonomics at Olin - LCAAP

by William L. Czeschin

William L. Czeschin is Industrial Engineering Methods and Standards Supervisor for Olin Defense Systems Group at Lake City Army Ammunition Plant. He is an Adjunct Professor for the University of Missouri - Columbia Industrial Engineering Department, where he received his MSIE Degree.

Bill is involved in the Olin - LCAAP Ergonomics Program and is a member of the Ergonomics Task Force (ETF) Committee where he has conducted plant ergonomic training sessions.

Bill is a Senior Member of the Institute of Industrial Engineers and is a Past President of the Greater Kansas City Chapter, where he is Director.


Introduction

Evaluating projects effectively is based on viewing the total picture. For example, purchasing must consider manufacturing when purchasing parts. Questions must be asked such as, "How, if any, will the purchased part affect production?" Likewise, a VE analysis must include what impact the completed project will have on the human body. Not only are people the company's biggest asset, but morale will improve because of the concern for people.

Ergonomics is a key part of the big picture that must be considered in evaluating projects. Some experts, including Occupational Safety and Health Administration (OSHA) have even predicted that ergonomics will be a top issue of the 1990s. Ergonomics is simply fitting the job to the person but, in reality, most workers have had to adapt to the task. How do ergonomics and human factors fit into VE?

Traditionally, most of the VE definitions and related activities have not concentrated on human factors. For example, Lawrence D. Miles defined Value Analysis (VA) as "an organized creative approach which has for its purpose the efficient identification of unnecessary cost, i.e., cost which provides neither quality nor use nor life nor appearance nor customer features." SAVE perceives VE as the systematic application of recognized techniques to identify the functions of a product or service and to provide those functions at the lowest total cost. Although VE definitions do not specifically identify human factors as a concern, it is implied that the effect on people is to be considered in VE projects as well as many other criteria.

Ergonomics Development as a Management Tool

Ergonomics is derived from the Greek words, "ergo," meaning work, and "nomos," meaning natural laws. Thus a strict definition would be "the laws of work." However, a more descriptive definition is a multidisciplinary activity dealing with the interactions between man and his total working environment. Ergonomics reduces physical strain by redesigning tools and equipment, reorganizing workstations, and changing the workplace environment. However, ergonomics is often most effective in reducing strain by cutting back on the stress and the number of repetitive motions performed on the job.

Ergonomics or human factors is not new. Since the beginning of time, man has always tried to adapt his tools and working environment to his needs and capabilities. Industrial Engineering has a tradition of considering the worker an integral component in a complex production or service system. F. W. Taylor, at the end of the nineteenth century, and the Gilbreths in 1912 specifically made note of how a worker's physical capabilities had to be carefully considered when designing a job if total system performance were to be maximized. In fact, the Gilbreths made quantitative studies of reach capability that formed the basis for many workplace layouts today.

What OSHA and employers are learning is that making the same motion over and over or working in a position or with equipment that does not fit the body can cause physical problems. One of the most common of these problems is carpal tunnel syndrome (CTS), resulting in pain and numbness in the wrists and hands. Surgery is often required to alleviate the condition.

Many clues can indicate that an inadequate work situation or design exists. These include high absenteeism, turnover, first aid cases, accident frequencies, and employee complaints, in addition to workers' modifying the workplace such as bringing extra cushions for their chairs, or modifying equipment. In these incidences, it is very probable that the job was not designed properly by fitting the job to the person.
Thus, ergonomics is a tool that can assist management or VE analysts in pinpointing areas where specific improvements can be made. The purpose of ergonomics is to fit the job to the person to create a safe, efficient and productive operation, and it is an excellent way to support the Total Quality Management (TQM) process of continual improvement.

### Justification for Including Ergonomics in VE Projects

Analysts today need to be aware of many factors, to be effective. Specific benefits resulting from including ergonomics as an integral part of VE projects are:

- Buffers companies' vulnerability.
- Increases analysts' expertise and awareness.
- Identifies opportunities for improvement.
- Indicates management's commitment and concern for people.

**Buffers Companies' Vulnerability**

Companies need to address ergonomics and take a positive rather than reactive role in regard to preventing ergonomically related disorders. OSHA has and will continue to issue citations against companies that have a high incidence rate of Cumulative Trauma Disorder (CTD), which are the result of repetitive motions have on the body over time. Although ergonomics is a broad area, OSHA is concentrating on CTDs, since 48% of occupational illnesses were CTDs in 1988, as compared to 39% in 1987, and only 16% in 1981.

Recent penalties proposed by OSHA and settlements indicate that OSHA is serious about controlling and improving ergonomics in the workplace. For example, in 1990 Ford Motor Company agreed to a $1.2 million settlement versus $2.0 million in proposed fines, and is to establish a corporate-wide ergonomic program that includes job analysis for ergonomic hazards, engineering and administrative controls, employee training and education, an extensive medical management program, and annual ergonomic audits. According to OSHA, one way to prevent this from occurring is to establish an ergonomics program involving both management commitment and employee involvement instituting the changes necessary to produce an ergonomically sound work environment.

**Increases Analysts' Expertise and Awareness**

VE Analysts' knowledge and awareness of ergonomics are necessary in evaluating and implementing VE projects. Not only is the analyst better prepared to analyze projects more efficiently, but the ultimate ergonomics goal of designing projects correctly to prevent undue stress on the human body is more likely to be achieved.

**Identifies Opportunities for Improvement**

Including ergonomics in VE projects can result in identifying opportunities where improvements are possible. These include the following areas:

- Higher worker morale
- VE and cost reduction projects
- Higher productivity
- TQM process of continual improvement.

**Higher Worker Morale**

Higher employee morale will exist when workers know that the company and engineers are genuinely interested in their well being by trying to make the job fit the worker. Much can be gained by listening to the workers, observing how the body is being used, and taking corrective action. Replacing the "do it the best way you can" with "the company cares about you" attitude not only increases morale but can improve productivity.

**VE and Cost Reduction Projects**

Ergonomics can help identify VE and cost reduction projects. The same basic questions VE analysts ask when analyzing or designing workplaces apply to ergonomics, such as, "Can it be done faster, simpler, cheaper or easier?" Integrating human factors in VE analysis not only makes the job safer and more efficient, but productivity increases as well.

**Higher Productivity**

Ergonomics will result in higher productivity by eliminating unnecessary steps, thus making each move more efficient. Safety will improve by considering the human body and workplace design resulting in a significant savings by reducing ergonomic related problems.

**TQM Process of Continual Improvement**

Ergonomics is a tool that can be used to support the TQM process of continual improvement. When the work environment is enhanced, improvements can and will result.

**Indicates Management's Commitment and Concern for People**

VE projects that include ergonomic issues indicate to workers that management is concerned about people and how the workplace design affects them directly. This personal touch results in mutual trust and illustrates upper management support is present, which is crucial in any project.

### Olin - LCAAP Ergonomics Program

Olin - LCAAP is committed to incorporating ergonomics as a way of life at Olin - LCAAP. The ergonomics program was initiated in the Spring of 1990 and is led by the Ergonomics Task Force Committee (ETF). The ETF is a cross section of the plant and has representatives from Safety, Medical, Manufacturing Engineering, Industrial Engineering, and hourly employees. The team identifies, prioritizes, and recommends solutions to address ergonomic issues. Management supports the ergonomics efforts, and, in addition, a corporate Olin Ergonomics Program has been established. Currently, many projects have been identified, several of which involve VE.

### Olin - LCAAP Ergonomics Projects

Projects to date involve a wide range of activities. Although each project is unique, all have a common goal of fitting the job to the person. Following is a partial list of ergonomic projects at Olin - LCAAP:

- Provide removable platforms in packing
- Modify machines to include footrests where applicable
- Redesign and modify carts and buggies
- Provide tool analysis
- Evaluate chairs in manufacturing area
- Eliminate tab pulling

**Provide Removable Platforms in Packing Area**

Platforms were provided to accommodate a wide range of heights. The packers have the option of using...
the platform which allows for a more individualized workplace to meet their special requirements.

Modify Machines to Include Footrests Where Applicable

Machines were modified to allow for footrests where feasible. This allows the workers to rest when standing and helps eliminate numerous problems from excess standing, including varicose veins.

Redesign and Modify Carts and Buggies

Carts and buggies are used in numerous operations, and, if designed correctly, can significantly reduce body stress. Prototype "ergo" buggies are being developed for unique operations. Several factors being addressed are height of buggies, removable sides, stackability, placement and type of handles, ease of buggy movement, and tilt features to avoid excess bending and reaching when removing parts from buggy.

Provide Tool Analysis

Many operations have been analyzed involving the use of tools. Tools are an extension of the body, and proper design can greatly increase the chances of reducing injuries. Several improvements involving tools were made including a "bio curve" mallet allowing the wrist to stay in a neutral position, and developing an ammunition can tool to assist in opening cans to reduce force exerted.

Evaluating Chairs in Manufacturing Areas

Chairs were evaluated to accommodate as many different sizes and shapes of people as possible. Desirable ergonomic chair features include adjustable height, tiltable and cushioned seats, adjustable back supports, stable five leg base, and adjustable foot rings. Currently, chairs are being replaced with "ergo" chairs as both time and resources permit.

Eliminate Tab Pulling

Links needed for packing come into the plant in tubes inside a carton. Before the links can be fed into the cartridge link feeding machine, it is necessary to manually remove the tabs from the top of the tubes, which is performed by the operator pulling up and twisting off each tab inside the carton. This highly repetitive motion causes the wrist to be in an awkward position, exposing the operator to CTD. It has been proposed to have the vendors supply the tubes without the tabs on the top end of the tubes. This would eliminate the tab pulling, resulting in a safer operation as well as a VE cost savings.

The projects described illustrate that improvements can be made to many types of activities involving ergonomic issues. Ergonomics is a word that all VE analysts should become familiar with as we enter the 1990s.

Conclusion

Olin - LCAAP has obtained significant results since implementing an ergonomics program in 1990 that attempts to fit jobs to the people. VE analysts need to incorporate ergonomics principles in projects to obtain similar benefits:

Increases VE Analysts' Effectiveness

By including ergonomics as an integral part of the analysis, chances of successfully implemented projects are increased. In addition, the ultimate goal of designing projects correctly to prevent undue human body stress is more likely to be achieved.

Buffers Companies' Vulnerability

Chances of receiving OSHA citations for ergonomically related issues are greatly reduced when a positive approach is used. Prevention is the key for many issues, including ergonomics.

Identifies Opportunities for Improvement

Many opportunities exist when ergonomics is included in project analysis. These include higher worker morale and acceptance, VE and cost reduction projects, higher productivity and supports the TQM process of continual improvement.

Unlimited Applications of Ergonomics in Value Engineering Projects

There are no VE projects where ergonomics principles should not be evaluated. In fact, the extent of including ergonomics in projects is only limited by the knowledge, expertise, and creativity of the analyst. The benefits of including ergonomics as outlined are great. Any analyst or company should incorporate ergonomics into VE projects.

References

Dare We Think Differently

by Luis M. Venegas, PE, CVS

Luis M. Venegas, P.E., CVS, is Director of Marketing and Manager - VE Services for the cost engineering firm of Project Time & Cost in Atlanta, Georgia. He received his Bachelor of Science in Architectural Engineering from the University of Miami, Coral Gables, Florida in 1972 and is a registered Professional Engineering in the Commonwealth of Virginia. Mr Venegas is the Secretary and Treasurer of the Atlanta Chapter of SAVE and has been a member of SAVE since 1984.


Value Engineering (VE), two words conjuring images of cost reductions, costly redesigns, cheapened products, additional work, time lost, fruitless effort and lost productivity. A bleak picture during these times of government cutbacks, deficits, and tighter purse strings. Yet the reality of VE within the design/construction community seems to prevail along those lines. Taken out of context and looked at as individual words, VE lends itself to this criticism; e.g.:

Value: "...precise signification"; and
Engineering: "...the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people in structures, machines, products, systems, and process."2

Independently, these words imply a set of strict, rational, inviolable outcomes conforming to some known standard or standards. Admittedly, some liberty has been taken to use these particular definitions to initially funnel the reader's thoughts along a very narrow path.

Let's now broaden that path and look at several definitions of VE and see the other side:

"...a systematic effort directed at analyzing the functional requirements of . . . systems, equipment, facilities, procedures and supplies to achieve the essential functions at the lowest total cost consistent with the needed performance, safety, reliability quality and maintainability."3

"...creative, organized approach whose objective is to optimize cost and/or performance of a facility of system."4

"...a systematized approach to seek out the best functional balance between the cost, reliability and performance of a product or project."5

Simply stated, VE is an organized technique of attaining a basic function at the least possible life cycle cost without degrading the integrity of the project, product or system.

VE is an organized technique of attaining a basic function at the least possible life cycle cost without degrading the integrity of the project, product or system.

This being the case, then why in this particular field of endeavor do we have an overwhelming resistive attitude towards the use of VE? To answer this question, one has to look at a two-pronged response: (1) habits, and (2) psychological factors.

Habits

Engineers, and to some extent architects, have by tradition been engaged in very precise and relatively unyielding disciplines that do not allow for speculative or untested results. This is evidenced by scanning any of innumerable accredited colleges' and universities' curriculum handbooks listing among their required courses: analytical and solid geometry, differential and integral calculus, Laplace transform, matrix algebra, trigonometry, statistics, chemistry, physics, thermodynamics, dynamics, strength of materials, statics, etc., to name a few. It is not the intent to belittle the

1 Value World, Jan./Feb./Mar., 1992
requirement for the knowledge to be gained from these curricula, but to point out that the majority of engineering courses are precise, scientifically tested theories with known anticipated results.

By formal training and education, engineers tend to be extremely analytical and pragmatic, rejecting change and unknown results. The methods and procedures of particular disciplines are inherently manifested to obtain a result arrived at in a logical, step by step means with little or no risk involved. Furthermore, experiences and traditional means are emphasized over and over again; the proverbial syndrome of “if it was good enough for my father and his father, then it’s good enough for me;” prevails throughout the profession. Engineers have therefore become creatures of habit and engineers tend to follow such philosophies.

Although all habits are not necessarily bad, they can become too rigid and inflexible, encircling us into steadfast results realizing designs and solutions containing unnecessary costs. Habits create a greater problem of being the foundation of roadblocks, mind-sets and fixed attitudes. By listing some of these “blinders,” we might better see some of the reasons leading to the resistive nature being encountered by engineers - as engineers might hear them.

Only the front office can approve this.
It’s too new.
It’ll take too long to review.
Lead planners won’t like it.
You want an answer - NO!
The owner has plenty of money.
That’s the way we’ve always done it.
It’s not covered in the specifications.
Policy/criteria dictates otherwise.
Are you kidding?
Who cares?
We don’t have the time to make changes.
It can’t be done.
It won’t work.

The list could go on forever; suffice it to say these, and many other bad habits, have inhibited change and the potential for shared new knowledge. Perhaps the following phrase best sums up the dichotomy of habit and knowledge:

“Knowledge is fluid, always changing, always growing, very often requiring you to let go of a firmly held idea. Habit is just the opposite. Habit is rigid, unbending, unchanging, unyielding, and naturally, because knowledge and habit are so diametrically opposed to each other, they often get in each other’s way.”

**Psychological Factors**

Having only lightly touched on the subject of habits, let’s turn our attention to the psychological factors contributing to resistive attitudes in engineers. Neither of these subjects, i.e., habits and psychological factors, can be discussed independently for both are intertwined as indicated above. Looking back at the list of “blinders,” several of them can easily be labeled as negative criticism; e.g., it can’t be done, it won’t work, etc.

In the VE world whose foundation rests with creative thinking, negative criticism can become the harshest of realities. Simply defined, criticism is the act of: “finding fault with; pointing out the faults of;” it doesn’t matter that the same source also defines criticism as the act of: “considering the merits and demerits of and judging accordingly: evaluate.” Once nonconstructive negative criticism is encountered, a withdrawal process begins within an individual, stifling new ideas and developmental growth; growth that is not only important and good for the individual, but also for the organization and profession.

To better understand this behavioral process, let’s very briefly look into the development of a young child, who by most accounts is the perfect example of a creative thinker. Nothing he encounters is impossible, from being able to see dragons and elephants in clouds to seeing a beautiful rainbow in a polluted stream of water. No obstacle gets in his way; he can fly higher and faster than any airplane or rocket; he can swim to the deepest depth of any ocean without artificial means for survival; he can be anything he wants to be and do the impossible for he is without bounds, without limits; a true dreamer of dreams.

As time passes and he enters his formal educative years, reality creeps into his world of mystical bubbles and he is soon told grass is green and only green; the sky is only blue and he can no longer color without going outside the lines. He encounters words of sharp criticism like “boy that’s dumb” or “how stupid can you be” or “you can’t do that.” Soon his attitude starts to change and by the time he reaches the work force, he has been conditioned and molded to act with caution, not to rock the boat, to stay within known limits, to be logical and practical under any circumstances, not to do something different!

Again, it is not the intent to belittle formal education; without it no knowledge would ever be gained and the basic tools of any profession would never be learned. But because the process to attain this knowledge is usually in the form of strict rules and regulations of linear conceptual memorization, signals are emitted tending to lead any individual into believing that to err is not human, to make mistakes is wrong and that curiosity will result in failure. In other words, don’t question what’s being said or taught, accept the “nature of the beast” for that’s the way it has been done and will always be done.

In the long run, the child who started out as the model creative thinker learns he doesn’t like feeling “dumb” or “stupid;” i.e., fear of ridicule; and to explore his curiosity could end in failure. Ultimately, his creativeness is “LEARNED-OUT”!

**Creativity**

A very bleak picture has been portrayed of our profession. In reality of course, it has been greatly
exaggerated, but not totally untrue. So where does this leave us? Why then, should engineers, particularly in design and construction, DARE TO THINK DIFFERENTLY, dare to be creative, dare to achieve a better basic function?

In her paper "Freedom to be...Creative," Sidney R-Bonvallet wrote:

"...The greatest contribution we can make to an organization is to break with routine and use our creative power to breathe new life and vitality into our jobs. We must be vigilant in our efforts not to expend all our energies on 'just keeping things going' to the neglect of innovation. An organization is energized by its use of the creative mind and grows sluggish just 'turning the crank.'

Engineers must plug into that energy field of creativeness for we cannot afford to "just turn the crank." Our industry is changing and improving with new methods, technologies and materials at an every increasing rate. Change, the one guaranteed "constant" in life, will occur regardless of our fruitless efforts to resist it. Engineers can look the other way and ignore these new-found creations or confront them head-on and look for the opportunities and possibilities that have become available.

Change, the one guaranteed "constant" in life, will occur regardless of our fruitless efforts to resist it.

Examples abound for reasons to accept newly created materials and technologies. Not only from the cost point of view, but from the ease of construction to the operational aspects for the owner. The use of plastic conduits for the transmission of fluids is not only less costly, but can be installed in half the time and repairs can be done easily with minimal tools and without extensive skills. The use of pre- and post-tension concrete, without expensive forms and labor, in innovative application provide a virtually maintenance-free system. The use of energy-saving, long-lasting ballasts and lamps have proven to be extremely cost effective for owners by reducing stock quantities and minimizing labor to replace them. Synthetic materials for wall and floor coverings are less costly to purchase and install, and due to their inherent longevity, ultimately reduce operational and maintenance costs.

But these creations didn't "just happen" (although in some cases it is possible, as we shall see later), they were the outcomes of creative minds seeking new and bold innovations, albeit inventions, never thought possible. How then, can we turn the tide against complacency? How can we overcome the effects of "LEARNED-OUT" creativeness and become re-creative? How can we DARE TO THINK DIFFERENTLY?

Creativity - the quality or ability to be creative, to produce or design through imaginative skills, to create, to bring into existence something new, invent; the act of creation. Aristotle stated the psychological basis for creative thinking is the association of ideas applied under three basic laws:

- **Similarity**: like ideas;
- **Contiguity**: adjoining ideas; and
- **Contrast**: opposite ideas.

Let's look at these laws to better understand their potential in the creative process.

**Similarity**: the association of likeness or resemblance - a painting of a ballerina's shoes might remind someone their shoes need polishing - a picture of a shark might remind someone of their aquarium at home.

**Contiguity**: the association of proximity or adjacency - a picture of hot air balloons might remind someone of freedom or lightness - seeing a gift reminding someone of the giver.

**Contrast**: the association of opposites or dissimilarity - black to white - good to bad - hard to soft.

Knowing this is the manner in which our mind works when we create, i.e., thinking creatively, then let's further explore the creative process. It is generally categorized into three main areas:

**Imagination** - a deliberate process requiring a tremendous amount of enthusiasm and energy. Ralph Waldo Emerson once said: "...nothing great was ever achieved without enthusiasm. It is the key to our imagination." Albert Einstein commented: "man's imagination is more important than his knowledge."

In a final note about imagination, Sidney R-Bonvallet wrote: "Enthusiasm is infectious...we 'catch' its power in those magic moments of delight with life."

**Inspiration** - the result of accidental stimuli also requiring a great deal of energy, can normally be directly linked to the stimulus. One has to be aware of and search for inspiration. Dr. Seuss (Mr. Theodor Seuss Geisel) was inspired to write books for children such as *The Cat in the Hat* to stimulate their imagination and to think along untraditional avenues. In their VA Workshop Seminar, presented during the 1984 SAVE International Conference in Sacramento, the staff of Value Analysis wrote: "Doctor William Easton said: 'Some people deliberately hunt for inspiration as one hunts for game. They go where they are likely to find it; they keep constantly on the alert for it. Although inspiration is uncontrolled, the chance that it will occur can be increased by enlarging the stock ideas in the mind and by multiplying observation.'

**Illumination** - very simply stated, it just happens. Illumination is neither on purpose, nor by chance; it's spontaneous. It is likened to a rainbow appearing during a rain shower - there it is - no question, no reason, no purpose, it just appears. It can happen anytime, anywhere, and, very importantly, to anyone.

We've seen how creativity has been studied, defined and manifested. But the question of *HOW* to think creatively is still left unanswered. Three basic questions need to be explored before a final answer can be rendered: (1) WHO is creative; (2) WHAT curtains,
stifles, or inhibits creativity; and (3) WHAT incites, stimulates, or motivates creativity?

WHO is creative?

Small Children - We've already seen small children are extremely adept at being creative. Their world exudes with curiosity and enthusiasm; they never cease to explore, ask, seek, and ultimately find, discover and enjoy.

Pioneers - Not only our early American pioneers who with little equipment were able to carve new lives and inroads in our nation, but modern pioneers such as scientists, astronauts and aquanauts. Pioneers venture into the unknown; usually wrongly, or ill-equipped to handle the adversities they may encounter, and yet they survive and go on with their imagination, ingenuity and creativity to help overcome great odds.

Housewives - Their ingenuity and imagination to constantly solve everyday problems with only what is at hand is remarkable. A housewife's ability to continually combine day to day items for new uses or solutions is unprecedented. One late winter night, my son remembered he was required to present a diorama around the habitat of an armadillo the next morning. Although we had company that night unabling me to assist my wife and son, she was up and around searching for items to be used. Within one hour, they had completed the diorama to include trees, ponds, grass, moss, etc., and the armadillo. Bark chips, kindling wood, shoe box, cotton, crayons, moss, paint, foil, tulle, string, paste, paper, mirror, and many more items were fashioned into a complete habitat. The combination of these materials, not originally intended for those purposes and uses, resulted in my son's A+ grade the next day.

Architects - Like artists; i.e., painters, sculptors, writers, poets, and musicians, have the ability to combine, add, delete and utilize new, as well as old, materials and produce unique examples of their minds' creativity.

Engineers - Although previously pictured as a rather "bleak" group of resistive individuals, engineers are known to be very inventive and imaginative. They, like architects, must have the ability to combine a myriad of materials, methods and principles into new and different designs.

Needless to say, this list could be expanded ad infinitum. However, the potential is in everyone to be creative through enthusiasm, imagination and motivation.

WHAT curtails creativity?

We've already seen how habits and psychological factors inhibit creativity. Let's just highlight some of these general categories:

Emphasis on the negative.
Strict guidelines and procedures.
Peer pressure to conform.
Fear of ridicule.
Fear of the unknown.

Charles F. Kettering, who invented the electric self starter by admittedly going outside the known principles of electrical engineering of his time, made the following statement regarding new ideas:

"Man is so constituted as to see what is wrong with a new thing, not what is right."[14]

Our creativity has been "LEARNED-OUT" by past negative experiences that in the majority of cases, is not consciously obvious. Unfortunately, we have the uncanny ability, through our subconscious mind, to maintain a running tally of those negative experiences; each one adding to our encircling, steadfast, safe, secure and misconstrued haven of rejecting. As Sidney R-Bonvallet wrote:

"We are capable of generating a self-fulfilling cycle so poignantly described by Harry Myers:

The minute YOU say a thing can't be done, YOU are through with that thing. And no matter how much you know...even if you're an EXPERT; if YOU say 'IT CAN'T BE DONE,' YOU are through. And someone else knowing nothing about it, but thinking, 'IT CAN BE DONE,' now is a better man for the job than you."[15]

But let's stop looking at the negative side of this entire issue. Let's see the good side, the upbeat, "the light at the end of the tunnel."

WHAT incites creativity?

Dissatisfaction with the status quo - "restless aspiration for improvement."[16] Creativity impels us to strive for the betterment of what exists.

Wars - For as terrible as wars are, they are fortunately a fruitful, fertile field for creativity rising from desperation and necessity. A good example has been the rapid development of the airplane.

Ignorance - How often have ideas become realities because the inventors did not know "it couldn't be done?" The lack of knowledge can be a strong motivator for creativity.

Necessity - As the saying goes "necessity is the mother of invention." Our Nation's policy of maintaining a strong military complex to keep peace in the world has necessitated the continual development and advancement of our armed forces. Our self-imposed deadlines are in themselves motivators of creativity.

Knowledge - Under most circumstances, the more an individual learns about a specific subject, the more he wants to know. Knowledge breeds knowledge, which directly correlates to the fact that creativity breeds creativity.

Curiosity - It has been said, "curiosity killed the cat;" however, the saying continues with "but satisfaction brought him back." A dichotomy - perhaps; but in reality, we have a natural ability within us to be creative. Small children are great creators. We were once children with the same curious outlook on life and there is no reason now, or ever, to stop being curious.

Value World, Jan./Feb./Mar., 1992
Greed - If John Doe can do it, then so can I! Admittedly for the wrong reasons, but greed can spur us into doing and thinking of new and different ways to accomplish something just because someone else did it.

How to Think Creatively

We have seen that in most of us, creativity has been “LEARNED-OUT;” but what has been “LEARNED-OUT” can be re-learned. The key to re-learning our own natural ability to be creative stems from motivation, a willingness to know, and explore, to set ourselves free from constraints and dream the impossible. How do we go about re-learning creativity? Several excellent methods and techniques have been developed to enable us to freely express our inner feelings and allow the rebirth of creativity. It is not the intent here to explore in great depth any or all of these, but only to highlight the ones listed below for their proven success in VE:

**We have seen that in most of us, creativity has been “LEARNED-OUT;” but what has been “LEARNED-OUT” can be re-learned.**

Brainstorming - This method is known as Osborn’s Rules of Brainstorming. This being the most widely used creative thinking method in VE, it will only be discussed in terms of its four basic general rules:

- **No Criticism** - We’ve already seen negative criticism is perhaps the worst enemy of new ideas; therefore, no criticism is allowed. Do not judge any idea presented - give it a chance. Stated differently - “laugh with each other and not at each other.”

- **Frewheeling** - Let your imagination run free, dream, think of the impossible. An architect is as qualified to make a mechanical engineering suggestion as an electrical engineer is to suggest one about structural engineering. Encouragement and enthusiasm are key factors.

- **Quantity** - Create as many ideas as possible. Volume is being sought, not just one or two items, but 60, 70 maybe even hundreds.

- **Combine and Expand** - The basic philosophy here is to piggyback, or hitchhike, ideas. Let one be the expansion of another and/or combination of several. One idea can, and usually does, become the seed for several others.

Checklists - This method relies on a vast quantity of experience. Those ideas, having been generated at another time with known good results, are consulted for the instant project. This method appears to be extremely simplistic, yet it is based on the piggyback concept in brainstorming.

Nominal Group Technique - This too is a widely used technique and will only be discussed in terms of its six steps.

- **Introduction** - Introduces the project or problem to be tackled.

- **Silent Generation** - Each engineer and/or architect is allowed a short time to generate his own ideas on the instant problem. This method of creativity is very useful by individuals who come together for the first time as a team; it allows freedom of potential fear that is sometimes exhibited during face-to-face group discussion.

- **Presentation** - In round-robin fashion, each team member presents his ideas to the group and they are recorded. As in other techniques, no criticism is permitted to enter this phase.

- **Clarification** - After having all ideas recorded, they are discussed to ensure understanding by all members. During this phase, each idea is clarified and/or modified and the possibility of piggybacking can result in the combination of several ideas.

- **Ranking and Weighing** - Each team member selects the top eight ideas of all the ideas presented and then ranks them from one to eight, with eight being the best “grade.” How many voted for each idea and the sum of their ranking is recorded.

- **Discussion and Closure** - The top eight ideas, as determined by the ranking and weighing in the previous phase, are then selected for continued development and discussion along the VE process.

Gordon Technique - This technique also uses the concept of freewheeling as in brainstorming. It too is in the forum of a team conference in which freedom of expressing ideas is encouraged by having the team leader volley pertinent questions related to a project or problem. The principle difference with the Gordon Technique and other methods, is that only the team leader knows the actual problem or project.

Regardless whether one uses these or any other method or technique for the successful generation of ideas, which is the crux of all VE studies, five basic guidelines should be followed:

- **Express ideas free from criticism by suspending judgment until you reach the judgment phase of the job plan;**

- **Assume that each idea will work;**

- **Research ideas without restriction;**

- **Capitalize from cross-fertilization of ideas; and**

- **Participate in a competitive spirit.**
This leads us back to the original question: DARE WE THINK DIFFERENTLY? Without hesitation, the answer has to be - YES, YES and again YES!! We in engineering cannot, under any circumstances, be complacent with our past accomplishments, the status quo, or the immediate future. The inevitability of a changing universe will leave us in its wake, floundering like fish on dry land wondering why we've been left behind.

We must open our minds, re-learn that our own creativity is the present world of the future. Collectively we possess not only the knowledge of the past, but most importantly, the key to the future. For our profession touches every aspect of our daily lives, from our homes and offices, roads and highways, to our industrial, agricultural and business complexes. We have accomplished much during the short period VE has been in existence; but we must not stop, we dare, not stop.

Engineers must DARE TO THINK DIFFERENTLY! We must dream the dreams of our childhood's curiosities to fulfill the unknown. We must tap our font of creativity, imagination, ingenuity and always strive for the best solution, the best basic function. We must set ourselves free from the ties of our own "LEARNED-OUT" creativity.

An 85 year old woman from Louisville, Kentucky once wrote:

"If I had my life to live over, I'd dare to make mistakes next time. I'd relax, I would limber up. I would be sillier than I have been this trip. I would take fewer things seriously. I would take more chances. I would climb more mountains and swim more rivers. I would eat more ice cream and less beans. I would perhaps have more actual problems, but I'd have fewer imaginary ones.

You see, I'm one of those people who lives sensibly and sanely hour after hour, day after day. Oh, I've had my moments, and if I had to do it over again, I'd have more of them. In fact, I'd try to have nothing else but moments, one after the other; instead of living so many years ahead each day. I've been one of those persons who never goes anywhere without a thermometer, a hot water bottle, a raincoat and a parachute. If I had to do it again, I would travel lighter than I have.

If I had to live over, I would start barefoot earlier in the spring and stay that way later in the fall. I would go to more dances, I would ride more merry-go-rounds. I would pick more daisies."

Conclusion

We engineers of today and especially of tomorrow, must DARE TO THINK DIFFERENTLY! Dare to be: creative, imaginative, curious and ingenious. But most importantly, in our stress-filled, task-oriented world, we must stop and "pick more daisies" for when you have a dream, don't let anything dim it, keep hoping, keep trying - the sky is the limit!!

References

2. Ibid, page 412.
7. Webster's, op. cit.
8. Ibid.
12. R-Bonvallet, op. cit., p. 211.
16. Webster's, op. cit., p. 361.

Inspirational Influences

Venegas, Berta M., my wife
Venegas, Luis Michael, my son
Venegas, John Richard, my son
Barlow, Teresa A., Barlow Associates
R-Bonvallet, Sidney, Value Management, Inc.
Computer-Aided Project Management Tools

by Gamil B. Girgis, Ph.D., PE, CVS

Gamil B. Girgis, Ph.D., PE, CVS, is the president of Gulf South Engineers International, Inc. in Germany. He is responsible for the engineering and VE work of his organization.

Introduction

Managing a project is much like managing any other business effort. The key functions are planning, organizing and controlling the effort for it to be successful. A successful project is a quality product that meets the product’s specifications, stays within the budget and is delivered on schedule. These project functions must be closely bound by an adequate information and control system if project performance is to be properly measured and controlled.

Modern management planning and control can be dated from the development of the bar chart by Henry L. Gantt during World War I. The bar or Gantt chart represented a tremendous improvement over prior practices, and Gantt charts are still in very wide use to report project status. However, the increasing size, complexity, and risk associated with modern, technically sophisticated projects motivated the development of new methods. These methods are superior to Gantt charts for planning (by showing task interdependencies), for scheduling (by highlighting the critical path), and for control (by providing insights into time vs. resources tradeoffs).

Project Management Tools

Nearly all Department of Defense contracts require detailed scheduling and reporting, most Department of Energy contracts require similar information as does the National Aeronautics and Space Administration. Modern project management practices and methods are also widely used in the private industry.

Therefore, value engineers, specialists, and managers should understand and make use of project management tools such as Program Evaluation and Review Technique (PERT), Critical Path Method (CPM), Precedence Diagramming Method (PDM), Work Breakdown Structure (WBS), Resource Allocation, and Cost/Schedule integration.

Nearly all Department of Defense contracts require detailed scheduling and reporting, most Department of Energy contracts require similar information as does the National Aeronautics and Space Administration.

Many of these tools and methods date back to the 1950s, and their extensive computer-aided automation was developed during the 1960s. Their modern implementation depends upon the wide availability of economical computing power and display devices. There are many commercially available software packages that can be used to implement either all or parts of an information and control system very efficiently and at a reasonable cost.

A Historical Perspective

The DuPont Company, together with Univac, developed CPM in 1957-1958 for scheduling and planning plant construction and maintenance programs. The essentially identical method of PERT was conceived by the Special Projects Office of the U.S. Navy in 1957-1958, and developed by Booz, Allen, and Hamilton in conjunction with Lockheed Missiles Systems Division on the Polaris Fleet Ballistic Program where the dominant emphasis was on meeting stringent schedules for internationally strategic reasons and taking a rather flexible view on cost control.

Resource Allocation or leveling is the distribution of resources over a given time span. It attracted attention beginning in the early 1960s. Although this process is
not new, it is much more easily accomplished from a framework of PERT or CPM project network.

Following PERT/CPM, systems for tracking project cost by activity were developed in the early 1960s. Cost estimating by activity compares with the traditional method of take off of material quantities from drawings and specifications, estimates of material, unit costs, labor costs, and indirect costs. Theoretically, PERT/COST as a technique provides a tool for measuring project progress and for forecasting completion cost.

The PDM was introduced at Stanford University during the 1962-1964. PDM is the same method as PERT/CPM expressed in a new format which offers certain efficiencies in modeling concurrent tasks.

An important addition to the rapidly expanding body of modern project management methods also occurred in the early 1960s known as WBS. A WBS is a diagram of the work to be done, expressed in detail from the top down in a tree structure. A WBS establishes how the work will be performed and how cost and schedule data will be tracked and reported.

Integration of schedule, cost, and WBS in project management had been an illusive goal until the early 1970s. Currently, it is well established within the Department of Defense under the name: "Cost/Schedule Control System Criteria (C/SCSC)."

**Project Network Planning**

The basic premise of the project network planning method is that a network can be used to reasonably represent the performance sequence of a project. The key success is to logically apply knowledge, experience, and instincts to plan, then to schedule the project. A project network is nothing more than a graphic model of the project in the form of a flow chart. Network rules of logic are simple, but the network method is superior to traditional practices in exposing poor planning.

---

**The basic premise of the project network planning method is that a network can be used to reasonably represent the performance sequence of a project.**

---

It does not take longer to plan a project using network techniques than with traditional methods, but the network method yields more accurate and detailed plans. The cost of applying network methods, however, is small, perhaps no more than 0.5 percent of the project cost. Project time and cost savings return this investment several fold when these methods are successfully applied.

Which projects should be networked? Usually any project of $1M in cost or greater can benefit from applying network methods. The detail to be included in the average activity is a matter of judgement. The type, duration, cost, and risk in the project are all factors to be considered.

**Computer-Aided Project Control**

PERT/CPM/PDM computations are very simple. A small network with 50 activities can be calculated by hand, but larger networks, of say 500 activities and up require automation.

The availability of mainframe computers in the 1950s led to the development of PERT/CPM/PDM Network Analysis Programs, or NAP as they became known, to perform project network calculations. Modern NAPs can accommodate very large projects, e.g. 50,000 activities or more.

Features of the modern NAPs include the ability to do both PERT/CPM networks; resource allocation; compute project and task estimates for labor, capital, and other resources; and accept inputs on actual costs and resource commitments. Some provide for summarization by the project work breakdown structure, by budgets, and they are available to compute current and cumulative variances between plan and actual cost/schedule information for integrated presentation and also enable selection, processing and display.

The resource allocation or leveling ability of modern NAPs permits the user to specify the priority rules to be used. The computer then develops an optimum schedule, saving the user considerable time. Resource allocation systems make "what-if" simulation feasible. A great advantage in VA.

Resource allocation is of critical importance to multiproject planning and scheduling. In spite of the substantial amount of concurrency among activities, there is often enough flexibility in the schedules of individual projects that resource allocation yields substantial savings.

Today, project management software makes the search for cost alternatives more feasible. And a must for large VE projects. If each activity has a normal as well as a crash time and cost estimate, and work must be expedited to meet or compress the schedule, analysis is required to select the optimum strategy of increasing cost to save time. This problem is ideal for the computer which can be programmed to search for the minimum cost solution on the critical path.

The second main application of computers to modern project management is automated project graphics. Software is available for mainframes, minis, workstations and PCs. It produces network drawings, bar charts, work breakdown structures, and cost/resource diagrams.

Today's software works with many types of screen devices, pen plotters, electrostatic plotters, laser and dot matrix printers and with a wide variety of input devices.

**Automation Benefits**

The quantitative benefits of project graphics automation are impressive in time savings and cost savings. However, the qualitative benefits of improved...
performance of project managers and the accuracy of their decisions can far exceed the quantitative of automating a previously manual process. The quality of project management is directly related to the availability of clear, concise, and timely project status information as the basis of good decisions.

Data manipulation, extraction, and relevant presentation are facilitated with an automated system capable of generating a wide variety of graphical reports. Trouble spots are highlighted and can be traced to the level of detail required to isolate the cause of the problem and its resolution.

Conclusion

Project success is completely dependent on adequate planning, direction, scheduling, monitoring, and control. The power, utility, simplicity, and validity of modern project control methods have been proven in thousands of situations. A great variety of information and control system hardware and software packages are available for the prospective implementer of project management.

In many cases the use of a particular tool such as PERT/CPM, PERT/COST, PDM, WBS, Resource Allocation, and Cost/Schedule integration will be a contractual requirement. The use of WBS and one of the networking planning and scheduling tools are almost a necessity for every project. The WBS is made even more effective if it is made part of an integrated cost schedule control system.

A very small improvement in overall project management can justify automation. Just 1 percent cost savings on a relatively small $10 million in cost project, or a savings of $100,000 will buy an assortment of project management automation technologies that can be repeatedly applied to projects tens of times larger to yield similar savings.

Example #1

<table>
<thead>
<tr>
<th>Hospital Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VE Proposal:</strong></td>
</tr>
<tr>
<td><strong>Proposed Savings:</strong></td>
</tr>
<tr>
<td><strong>Basic Function:</strong></td>
</tr>
<tr>
<td>**Utilities would be easily accessible from this space.'</td>
</tr>
<tr>
<td><strong>Secondary Function:</strong></td>
</tr>
<tr>
<td>**Repairs to the hospital utilities could be made without disruption of the patient care functions.'</td>
</tr>
<tr>
<td><strong>Reason for Rejection:</strong></td>
</tr>
</tbody>
</table>

**VE Impact:** Further analysis could have been presented to meet the secondary function of "Evaluate Quality." Additional discussions with the owner during the analysis phase may have clarified the importance of this secondary function.

Example #2

<table>
<thead>
<tr>
<th>Personnel Support Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VE Proposal:</strong></td>
</tr>
<tr>
<td><strong>Proposed Savings:</strong></td>
</tr>
<tr>
<td><strong>Basic Function:</strong></td>
</tr>
<tr>
<td>**Prevent moisture penetration into building.'</td>
</tr>
<tr>
<td><strong>Secondary Function:</strong></td>
</tr>
<tr>
<td>**Labor requirements to repair the roof should be minimal, and a &quot;low-tech&quot; approach should be used.'</td>
</tr>
<tr>
<td><strong>Reason for Rejection:</strong></td>
</tr>
</tbody>
</table>

**Did the proposal meet the basic function?** Yes
**Were aesthetics involved?** No
**Did the proposal challenge the design criteria?** Yes
**Was the idea a new material or technique?** Yes
**Were examples of other applications of the idea presented in the proposal?** No
**Were the disadvantages of the proposal solved or minimized?** No
**Who rejected the proposal? Owner or Designer?** Owner
**Was the project over budget?** No

**VE Impact:** Further analysis could have been presented to meet the secondary function of "Enhance Quality."

Example #3

<table>
<thead>
<tr>
<th>Physical Fitness Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VE Proposal:</strong></td>
</tr>
<tr>
<td><strong>Proposed Savings:</strong></td>
</tr>
<tr>
<td><strong>LCC Savings:</strong></td>
</tr>
<tr>
<td><strong>Basic Function:</strong></td>
</tr>
<tr>
<td>**Typically, these exit signs are powered either by a battery pack, or an emergency generator.'</td>
</tr>
<tr>
<td><strong>Secondary Function:</strong></td>
</tr>
<tr>
<td><strong>Reason for Rejection:</strong></td>
</tr>
</tbody>
</table>

**Did the proposal meet the basic function?** Yes
**Were aesthetics involved?** No
**Did the proposal challenge the design criteria?** Yes
**Was the idea a new material or technique?** Yes
**Were examples of other applications of the idea presented in the proposal?** No
**Were the disadvantages of the proposal solved or minimized?** No
**Who rejected the proposal? Owner or Designer?** Owner
**Was the project over budget?** No

**VE Impact:** Further investigations with the owner could have identified this as a firm requirement.

References

How early can the principles of Value Analysis (VA) be meaningfully applied in a program's life cycle? We have been tackling this question for a number of years.\textsuperscript{1,2} Now we postulate that even the earliest activities can benefit from VA. We have found that the VE Job Plan provides a firm basis for preparation of Business Development Plans (BDPs). A BDP is a key element in the formation of a business enterprise to bring a new product or service (henceforth referred to as the product) to the market. It provides an operating plan for the enterprise and is also the traditional method of raising capital from outside investors. We offer three reasons why this subject should be explored in Value World:

- To continuously explore the application of powerful VA techniques to non-traditional endeavors,
- To highlight a new VE market area targeted at entrepreneurs, and
- To provide business planning information to VE practitioners who would like to start their own enterprise.

Developing a good business plan requires creativity, careful thought and a concerted effort by a small team of experts.

Preparation of a BDP follows a systematic approach which closely resembles the VE Job Plan. Illustrated in Figure 1, the BDP effort consists of six phases culminating in the presentation of the plan to potential investors. This effort is typically undertaken by a team leader hired by the entrepreneur. Depending on the product, the team usually led by an economist/accountant and would include a production engineer, a marketing specialist, and other appropriate consultants. There are several excellent commercial publications that provide guidance on the subject of business development planning.\textsuperscript{1-4} While there are no rigid rules for content of a BDP, general plan elements are listed in Figure 2. The content should be tailored to reflect the unique characteristics of each individual enterprise.

Preparation Phase

This is the period that the team leader uses to gather all the data and material needed for the BDP effort. Similar to the preparation of a VE study, schedules and required resources are identified. Dates are established for the focused generation of a complete plan.
Business Development Plan Six-Phase Workflow and Documentation

Presentation Phase

• Publication:
  - Edit
  - Print
  - Graphics
• Briefings:
  - To Client
  - Investors

Development Phase

Prepare Narrative, Graphics and Summary

Analysis Phase

Comparative Evaluation of Alternatives to Find Optimum

Speculation Phase

Speculative ideas and Alternatives

Information Phase

Organizational Objectives and Estimating Basis

Preparation

Costs and Schedules for Preparation of the Plan

Figure 1

Typical Business Development Plan Contents

• Executive Summary
• The Product(s)
• The Market
• Marketing Strategy/Plans
• The Company
• Operations/Manufacturing Plan
• Management
• Financial Information
• Basis for Financial Information

Figure 2

Information Phase

A period must be allocated for the team to gather, review and absorb the data on the product and market. Information describing the proposed product to be offered is examined. This information may range from the germ of an idea to prototype systems, depending on the nature and maturity of the proposed enterprise. Information should be gathered describing the product or service to be offered, the market in which it will be sold, and organizational, production, marketing, and distribution concepts. Regardless of the extent of concept development, the Value Analyst must be sure to completely understand the proposed enterprise just as would be expected for any VE study. Function analysis and cost modeling are VE techniques that can be used for a thorough understanding of the proposed enterprise.

An additional element of the information phase for BDP preparation is an understanding of the target market for the proposed product. Particular note must be taken of current market conditions, competition, and pricing to quantify the competitive environment.

Speculation Phase

In addition to speculating on alternative "designs" for the proposed product, this phase will address production, organization, and marketing. Structured creativity directed by the Value Analyst will help find alternatives which result in better and/or less costly products, more efficient production or organization, alternative marketing approaches, as well as the means to bring the product to market more quickly.

Analysis Phase

Having generated a variety of ideas regarding the product, marketing strategies, business organization and management approach, each idea must be subject to careful analysis, synthesis and appraisal. VA has developed the tools to achieve this goal and Value Analysts are trained in their application. In certain localities, business entities must be incorporated according to the appropriate regulatory and licensing requirements which must be recognized during the analysis phase.

The litmus test of the value built into a new product and the organization conceived to bring it to the market is its potential profitability. This requires that cost estimates be developed for each element or combination of elements of the emerging plan and development of multi-year financial projections. Financial projections are based on calculations and estimates and aggregated into high level figures rather than detailed line items. Pro forma financial statements are typically developed for five years to reflect future results, although shorter and longer periods have been used.

Mar., 1992
The scope of the market has to be thoroughly defined to permit an evaluation of the plan. When statistical surveys have been performed, the significant trends and most pertinent information should be extracted. If the scope of the marketing data compiled was on a national scale, and the product is to be introduced on a regional scale, the data source must be acknowledged along with the analyst's treatment of the statistics. The logic and reasonableness of this data must be made clear. An example of this application is illustrated in Figure 3.

Market Share Calculation Example

Example market size assessment based on 1988 U.S. National statistic.

Total potential users: 63 million

Los Angeles region potential users: 340,000

\[
\text{340,000 Potential users in region} \times 0.5 \quad \text{Assume 50\% of potential users reached} \\
\text{170,000 Assume 25\% of individuals reached purchase product} \times 0.24 \quad \text{Anticipated first year unit sales, Los Angeles area*} \\
\text{4,250} \\
\]

Figure 3

Development Phase

Concepts and approaches identified and evaluated in previous phases are developed into a concise BDP. This is where the selected course of action and pricing approach is described and correlated with the strategic plan for investment and marketing. The final document need not contain all the work sheets, detailed estimates, calculations and other back up data that was prepared in the prior phases. Rather, it should contain summary findings that led to the decisions that were made to formulate the planning. Figure 2 lists the contents of a typical plan.

While each BDP will be structured to meet the specific requirements of the proposed enterprise the following generalizations should be considered.

- A well written Executive Summary is critical to generating sufficient interest that a prospective investor will decide to read on.

A well written Executive Summary is critical to generating sufficient interest that a prospective investor will decide to read on.

- The material presented must be focused on demonstrating the viability of the enterprise. The plan should be made clear to the reader. In this respect, the technical and financial parts of the plan need to be written for the lay person, rather than a professional or specialist. Use of summary tables and graphics are encouraged to define or illustrate financial, corporate and organizational relationships, in addition to product functions or services to be offered.

- Brevity is an asset. The typical plan is 30 to 50 pages. Other data should be appended.

- Accuracy is essential. It is doubtful that anyone will find favor with a document that contains technical, computational or grammatical errors. Quality of the plan, its credibility and validity, can be established by assuring that it's content is carefully edited and checked.

- Avoid the use of unsubstantiated superlatives and non-assertive language.

- Appearance of the plan creates the first impression to potential investors. The plan must be of professional quality but not so "slick" that it detracts from the plan itself.

Presentation Phase

Typically, the BDP is presented to prospective investors for review and evaluation. If the investor develops an interest in the soundness of the enterprise a dialogue will be established with the entrepreneur and his team. The experience and participation of the Value Analyst at this stage will help to assure investors that the plan has been "Value Engineered" to enhance profitability while preserving the functional integrity of the product originally envisioned by the entrepreneur.

Pro forma/Financial Statements

While VE Proposals are costed using present value life-cycle techniques, BDPs rely on projected, or pro forma, financial statements. Price Waterhouse recommends the following statements be included: Profit and Loss Statement, Cash Budget, and Balance Sheet. They suggest that the five-year projections be presented monthly for at least one year, but not more than two, and quarterly or annually for the remaining years. The structure of each financial statement will be dictated by the nature of the business proposed.

Figure 4 illustrates one version of a balance sheet. The vertical grouping of elements to be displayed on the sheets, and an explanation of the line item calculations that will be made follows:

Revenues: The line item for revenues is the product of the two lines under it: "Units Sold" times "Unit Price." Remember that the unit cost is derived from the cost of sales, plus a profit margin that will service the investment costs.

Cost of Sales: This line item is the summation of the lines allocated below it to identify the cost of sales elements. The computation must relate to the number of "Units Sold" in the group above. Often the number of product units sold is less than the number of units produced because of rejection rates or the rate at which the products are produced. The elements in this group can include: "Direct Labor," "Cost of Materials," "Leases," "Shipping," "Marketing/Advertising," "Utilities" and other cost factors that are directly associated with production and/or services and sales. The analyst may choose to have line items for "Indirect

Value World, Jan./Feb./Mar., 1992 23
### Pro Forma Balance Sheet Example

<table>
<thead>
<tr>
<th>ITEM</th>
<th>YEAR</th>
<th>DATE</th>
<th>DATE</th>
<th>DATE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SALES REVENUE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units Sold</td>
<td>6,700</td>
<td>9,800</td>
<td>19,500</td>
<td>19,500</td>
<td>19,500</td>
</tr>
<tr>
<td>Income @ $2.545/Unit</td>
<td>17,052</td>
<td>24,941</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Income @ $2.570/Unit</td>
<td>-</td>
<td>-</td>
<td>50,115</td>
<td>50,115</td>
<td>51,090</td>
</tr>
<tr>
<td>Income @ $1.620/Unit</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>COST OF SALES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Manufacturing Cost</td>
<td>6,900</td>
<td>10,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Cost per Unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cost of Goods @ 1.773</td>
<td>12,234</td>
<td>17,730</td>
<td>35,460</td>
<td>35,460</td>
<td>35,460</td>
</tr>
<tr>
<td>- Royalties @ .05</td>
<td>345</td>
<td>500</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>- Manufacturing @ .08</td>
<td>552</td>
<td>800</td>
<td>1,600</td>
<td>1,600</td>
<td>1,600</td>
</tr>
<tr>
<td>Direct Manf. Cost</td>
<td>13,131</td>
<td>19,030</td>
<td>38,060</td>
<td>38,060</td>
<td>38,060</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mngmnt./Sales/Admin.</td>
<td>458</td>
<td>476</td>
<td>495</td>
<td>515</td>
<td>536</td>
</tr>
<tr>
<td>Travel &amp; Entertainment</td>
<td>20</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Advertising &amp; Promotion</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Utilities &amp; Telephone</td>
<td>25</td>
<td>26</td>
<td>56</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td>Maintenance</td>
<td>40</td>
<td>43</td>
<td>92</td>
<td>98</td>
<td>104</td>
</tr>
<tr>
<td>Rent</td>
<td>195</td>
<td>195</td>
<td>195</td>
<td>195</td>
<td>195</td>
</tr>
<tr>
<td>Insurance</td>
<td>60</td>
<td>60</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Depreciation</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Indirect Cost</td>
<td>1,138</td>
<td>1,170</td>
<td>1,303</td>
<td>1,336</td>
<td>1,370</td>
</tr>
<tr>
<td><strong>Total Cost of Sales</strong></td>
<td>14,269</td>
<td>20,200</td>
<td>39,363</td>
<td>39,396</td>
<td>39,430</td>
</tr>
<tr>
<td><strong>NET INCOME</strong></td>
<td>2,783</td>
<td>4,741</td>
<td>10,782</td>
<td>10,719</td>
<td>11,660</td>
</tr>
<tr>
<td>Provision for Tax/Dvndnd.</td>
<td>1,974</td>
<td>2,159</td>
<td>4,263</td>
<td>4,252</td>
<td>4,581</td>
</tr>
<tr>
<td>Net Income After Tax</td>
<td>809</td>
<td>2,581</td>
<td>6,489</td>
<td>6,467</td>
<td>7,079</td>
</tr>
<tr>
<td>Capital Expenditure</td>
<td>2,000</td>
<td>-</td>
<td>1,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Free Cash Flow</td>
<td>(1,191)</td>
<td>2,581</td>
<td>5,489</td>
<td>6,467</td>
<td>7,079</td>
</tr>
<tr>
<td>Cumulative Cash Flow</td>
<td>(1,191)</td>
<td>1,390</td>
<td>6,879</td>
<td>13,346</td>
<td>20,425</td>
</tr>
</tbody>
</table>

Costs’’ of management, accounting/payroll, insurance and legal costs. Alternatively these costs can be aggregated on a line for “Overhead.” The delineation depends on how the analyst approached the calculation. In either case, it must be explained in the section called “Basis for Financial Estimates.”

**Income:** On this line, the total “Cost of Sales” is subtracted from “Revenues.” Other alternatives to this line could include “Gross Income” if there are other line item adjustments needed to reach “Net Income.” Below the income line, other relevant line item choices for the analyst to consider to complete the plan can include: “Depreciation,” “Provisions for Tax/Dividend,” “Capital Expenditure,” “Free Cash Flow,” “Cumulative Cash Flow,” “Return on Investment,” “Real Property Asset Value.”

**References**

Risk Management for Value Practitioners

Jack V. Michaels, Ph.D., PE, CVS

Dr. Michaels is Chairman of the Board of Value Institute Incorporated in Orlando, Florida. He was a member of the faculty at Florida Southern College and of the senior professional staff at Martin Marietta Corporation. Dr. Michaels has been a frequent contributor to Value World and to SAVE Conferences.

This article is printed by permission of the copyright owner, Jack V. Michaels, Ph.D., PE, CVS and is an abstract of the author's forthcoming book Technical Risk Management which will be published by John Wiley & Sons, Inc., in 1992.

Introduction

The essence of value management (VM) is to ensure that the most cost-effective means are used to satisfy essential requirements from the viewpoint of life-cycle cost. All too frequently, however, one neglects to consider the risk inherent in the various alternatives under consideration and, consequently, the promise of cost saving by the chosen alternative is not realized.

This article presents some elements of risk management which should be considered by value practitioners in their analysis. Examples of the mathematics of risk management are included.

Risk Concepts

Risk can be defined in terms of hazards and perils. A hazard is that condition that may cause a peril to materialize whereas a peril is an event that will result in loss. Hazards and perils are probabilistic. The concern is for the probability of occurrence of the various outcomes of perils given the occurrence of some causative hazards.

For example, automobile accidents are perils that may cause injury, property damage, traffic tie-ups, or any combination of the three. These combinations are called outcomes. Perils are characterized as having one or more possible outcomes, each with a unique probability of occurrence.

Hazards are also characterized as appearing in one or more forms. For example, the hazards causing the peril of an automobile accident to occur could appear as poor road conditions, heavy traffic, excessive speed, low speed, careless or reckless driving, or any combination of the foregoing. Each of the latter would also have a unique probability of occurrence.

In the industrial world, hazards can include defective parts and material, poor workmanship, and tolerance build-up among the component subassemblies. The outcome of these hazards can include such perils as reduced output, and increased rework and scrap.

The perils of interest in the technical risk domain generally relate to functionality, affordability, and profitability. The causative hazards usually relate to intrinsic factors of product and process maturity, product and process quality, concurrency among dependent tasks, and certain extrinsic factors.

Extrinsic factors are those which are beyond the control of programs such as regulations and inflation. Conversely, factors within the control span of programs, such as design maturity and implementation realism, are intrinsic factors. Competition is both an extrinsic and intrinsic factors.

Risk Systems

The relationship between technical perils and hazards is called a risk system. Hazards and perils are generally hierarchical and decompose into sequentially
lower orders as indicated in Table I. This poses a problem of choice to the risk analyst since greater sensitivity of perils to hazards often occurs at the lower hierarchical levels.

**The relationship between technical perils and hazards is called a risk system.**

Note how perils at a given level become hazards at the next lower level in Table I. The hazard inadequate resources and the peril program cancellation are sometimes referred to as the boundary hazard and peril.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Perils and Hazards Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HAZARDS</strong></td>
<td><strong>PERILS</strong></td>
</tr>
<tr>
<td>Inadequate resources</td>
<td>Marginal design</td>
</tr>
<tr>
<td>Marginal design</td>
<td>Tolerance build-up</td>
</tr>
<tr>
<td>Tolerance build-up</td>
<td>Lot rejection</td>
</tr>
<tr>
<td>Lot rejection</td>
<td>Corrective action</td>
</tr>
<tr>
<td>Corrective action</td>
<td>Cost overrun</td>
</tr>
<tr>
<td>Cost overrun</td>
<td>Poor profitability</td>
</tr>
<tr>
<td>Poor profitability</td>
<td>Program cancellation</td>
</tr>
</tbody>
</table>

Risk management should consider hazard and peril combinations at all levels in the hierarchy. The number of combinations grows rapidly, however, as one proceeds down the hierarchy, and one needs to select those that offer the greatest return on investment for the effort expended.

It has been found in numerous investigation of this kind that not too many of the items in question account for the bulk of the effect. This is referred to as the Pareto effect and a form of Pareto analysis can be used to determine the point of diminishing return beyond which it is not cost effective to continue the analysis.

**Risk Causatives**

The causes of risk, which are also called risk drivers, can be categorized as technical, programmatic, and supportability. There is a high degree of interaction among these categories.

**Technical Risk Drivers**

Table II lists a number of sources from which technical risks can emanate. Technical risks are usually associated with the evolution of new products and processes and are very transitory. What is risky today may be routine a few years later.

The magnitude of technical risks is not just a function of the state-of-the-art. In large measure, it is also a function of requirements placed on products and processes by the engineering specialties of safety, reliability, maintainability and human factors. It is always advisable to do cost trades of reliability and maintainability with system availability as the measure of effectiveness.

<table>
<thead>
<tr>
<th>Table II</th>
<th>Sources of Technical Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical properties</td>
<td>Safety</td>
</tr>
<tr>
<td>Material properties</td>
<td>Requirement changes</td>
</tr>
<tr>
<td>Radiation properties</td>
<td>Fault detection</td>
</tr>
<tr>
<td>Testing validity</td>
<td>Operating environment</td>
</tr>
<tr>
<td>Modeling validity</td>
<td>New technology</td>
</tr>
<tr>
<td>Interface integration</td>
<td>Survivability</td>
</tr>
<tr>
<td>Software design</td>
<td>Reliability</td>
</tr>
<tr>
<td>Software language</td>
<td>Maintainability</td>
</tr>
<tr>
<td>Unique resources</td>
<td>Human factors</td>
</tr>
</tbody>
</table>

**Programmatic Risk Drivers**

Programmatic risks are essentially functions of the legal, economic, social, and environmental environments that influence or govern the production, sale, and use of systems, products, or services, and the processes whereby the foregoing are produced. Table III lists a number of sources from which programmatic risks can emanate.

Programmatic risks are generally disruptive. Disruptions in the implementation plan for systems, products, or services may be due to decisions at higher levels of authority than those in the program.

As indicated in Table III, this higher level of authority may be internal or external (e.g., extrinsic factors) to the organization to which the program belongs.

<table>
<thead>
<tr>
<th>Table III</th>
<th>Sources of Programmatic Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material availability</td>
<td>Safety</td>
</tr>
<tr>
<td>Personnel availability</td>
<td>Security</td>
</tr>
<tr>
<td>Facility availability</td>
<td>Environmental impact</td>
</tr>
<tr>
<td>Funding availability</td>
<td>Communication interfaces</td>
</tr>
<tr>
<td>Labor difficulties</td>
<td>Contractor stability</td>
</tr>
<tr>
<td>Political advocacy</td>
<td>Customer stability</td>
</tr>
<tr>
<td>Requirement changes</td>
<td>Regulatory changes</td>
</tr>
</tbody>
</table>

Perhaps the greatest source of disruption is the inability to forecast the growth and influence of extrinsic factors. The majority of the items in Table III are of this nature.

**Supportability Risk Drivers**

Supportability has special emphasis in the defense community where concern is exhibited for weapon system deployment, operation and support. The non-defense parallel to this is typified by customer support, service and warranty in the automotive and other high-technology industries.

Supportability risks comprise aspects of both technical and programmatic risks. It is worthwhile noting the approach to supportability in the defense community because of the strides which have been made, and because of the close parallel between supportability in defense and non-defense.
Supportability has special emphasis in the defense community where concern is exhibited for weapon system deployment, operation and support. The non-defense parallel to this is typified by customer support, service and warranty in the automotive and other high-technology industries.

Table IV lists a number of sources from which supportability risks can emanate. Note the reappearance of several sources which were given in the lists of technical and programmatic risks in Table II and III.

<table>
<thead>
<tr>
<th>Table IV</th>
<th>Sources of Supportability Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Personnel availability</td>
</tr>
<tr>
<td>Maintainability</td>
<td>Training</td>
</tr>
<tr>
<td>Operating environment</td>
<td>Fault detection</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Transportability</td>
</tr>
<tr>
<td>Operation and support equipment</td>
<td>Facility availability</td>
</tr>
<tr>
<td>Technical data</td>
<td>Safety and security</td>
</tr>
</tbody>
</table>

Source: Risk Management Concepts and Guidance, Defense System Management College

Risk Determinants

The classical risk indicators, schedule delay and cost growth, are reactive in that they appear after the fact of risk materialization. Risk determinants can be evolved from planned implementation for the system or product of interest.

Risk determinants are defined as *quantifiable attributes that serve as measures of risk delay and risk cost*. The concepts of risk delay and risk cost recognize the probabilistic nature of risk. For example, assume that the time and cost to effect a corrective action in a certain task is 12 months and $250,000, with a probability of 0.25 that the corrective action will be required. The risk delay is the product of 12 months and the probability of 0.25, or 3 months. The risk cost is ($250,000) (0.25), or $62,500.

The principal risk determinants from the viewpoint of technical risk are: 1) Product maturity; 2) process maturity; 3) product quality; 4) process quality; and 5) concurrency (i.e., overlap among tasks which need to be completed sequentially). The quantified measures of these determinants are called *risk determinant factors*.

Product maturity factors are described below. Similar factors can be derived by the reader for the maturity of processes, the quality of products and processes, and concurrency among dependent tasks.

**Product Maturity Factors**

Table V gives suggested values for the product maturity factor. The product maturity factor PMF is a statement of how experienced one is in the approach for developing the product rather than how far along one has gone in the actual development of the product.

<table>
<thead>
<tr>
<th>Table V</th>
<th>Product Maturity Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACTOR</td>
<td>LEVEL OF CURRENT DESIGN MATURITY</td>
</tr>
<tr>
<td>0.0</td>
<td>Production first-article* system tested successfully.</td>
</tr>
<tr>
<td>0.1</td>
<td>Production first-article subsystems or products tested successfully.</td>
</tr>
<tr>
<td>0.2</td>
<td>Production first-article assemblies tested successfully.</td>
</tr>
<tr>
<td>0.3</td>
<td>Production first-article subassemblies tested successfully.</td>
</tr>
<tr>
<td>0.4</td>
<td>Production first-article details tested successfully.</td>
</tr>
<tr>
<td>0.5</td>
<td>Brassboard** systems tested successfully.</td>
</tr>
<tr>
<td>0.6</td>
<td>Brassboard subsystems or products tested successfully.</td>
</tr>
<tr>
<td>0.7</td>
<td>Detail design of systems or products completed.</td>
</tr>
<tr>
<td>0.8</td>
<td>Functional design of systems or products completed.</td>
</tr>
<tr>
<td>0.9</td>
<td>Design approaches validated by analysis.</td>
</tr>
<tr>
<td>1.0</td>
<td>No design approaches known.</td>
</tr>
</tbody>
</table>

*The term *first-article* connotes that the item was produced and qualified with validated technical data packages and certified production tooling (v. Section 5.4.2).

**The term *brassboard* connotes a unit that is identical in form, fit, and function to its production counterpart but has not been environmentally qualified.

Factors range in value from 0 to 1.0. The factors are direct measures of risk delay or risk cost in that the higher the factor, the greater the risk delay or risk cost in bringing the particular system or product to the marketplace. A factor of 1.0 signifies twice the risk delay or risk cost or a factor of 0.5. A factor of 0 signifies that no risk delay or risk cost will be experienced in that particular system or product.

Consider, for example, a new product which had been tested successfully in brassboard form. A Product Maturity Factor (PMF) value of 0.6 is obtained from Table V. Initially, it was expected that another two years and an investment of $350,000 would be required to bring the product to the marketplace. From a risk management viewpoint, however, the risk time estimate and risk cost estimate would be considerably greater as shown below, indicating that management intercession is advisable.

The values of baseline time estimate (BTE) and baseline cost estimate (BCE) are used in the following equations for determining the effects of risk delay and risk cost:

(1) \( RTE = BTE (1 + PMF) \)

where \( RTE \) denotes *risk time estimate*, and

(2) \( RCE = BCE (1 + PMF) \)

where \( RCE \) denotes *risk cost estimate*. 

Value World, Jan./Feb./Mar., 1992 27
Substituting $BTE = 2$ years and $PMF = 0.6$ in Equation 1, and $BCE = $350,000 and $PMF = 0.6$ in Equation 2 yields:

(3) $RTE = (1 \text{ year}) (1 + 0.6)$

$= 1.6 \text{ years, and}$

(4) $RCE = ($350,000) (1 + 0.6)$

$= $560,000.

**Alternative Choices**

Assume, for example, that a VA study has identified two alternative approaches to implementing a certain system. Approach A would cost $450,000 and Approach B, $750,000. Although Approach A appears to cost much less than Approach B, the inherent risk in Approach A is significantly greater than that of Approach B. The question is really one of the relative risk cost of the two approaches.

The relationships are shown in Figure 1. The notations $PMM$, $PQM$, and $PCM$ denote multipliers which are equal to the terms given in parentheses in the right-hand sides of the foregoing equations. Specifically, $PMM$, $PQM$, AND $PCM$ equal $1$ plus the corresponding product maturity factor, product quality factor, and product concurrency factor.

The VA revealed that the product design is brand new, that shortcuts are being taken which affect quality, and that the accelerated schedule induces much task concurrency. Thus, the ratings are $PMF = 0.75$, $PQF = 0.90$, and $PCF = 0.65$ for $PMM = 1 +0.75$, or $1.75$, $PQM = 1 + 0.90$, or $1.90$, and $PCM = 1 + 0.65$, or $1.65$.

On the other hand, the product design in Approach B is fully mature, the quality is high, and the concurrency is extremely low. Therefore, the ratings are $PMF = 0.00$, $PQF = 0.10$, and $PCF = 0.00$ that yield $PMM = 1 + 0.00$, or $1.00$, $PQM = 1 + 0.10$, or $1.10$, and $PCM = 1 + 0.00$, or $1.00$.

The resultant risk cost estimates, $RCE$, are shown in the figure 1. It can be seen that the $RCE$ of Approach A is greater than that of Approach B; namely, $2,517,500$ versus $2,325,000$. A decision to use Approach B would be advisable.

**Summary**

This article presented some elements of risk management which should be considered by value practitioners in their analyses of alternative approaches. Examples of the mathematics of risk management were included. It was shown that the lowest-cost alternative approach does not necessarily yield the lowest risk cost estimate for the system.

**Footnotes**

Letter to the Editor

by Richard W. Siorek, PE

This is in reference to the fine article by R.W. Siorek "Value Analysis - Does it have a place in the sun?" - Value World July '91

As I went through this excellent article, it seemed to me as if every word had been written by myself. Many of us long-time VE practitioners have felt the same way but not always expressed ourselves so clearly, so gently and yet so convincingly as this "novice." In fact, the theme of my paper entitled "VE - Growing pains? Struggle for survival? or Both?" for the 1986 Conference in Paris was similar.

Now for Mr. Siorek's points: While there have certainly been many additions to book titles on VE, as witness Tom Snodgrass/M. Kasi, Theodore C. Fowler, Harold Tufly, Tom King, Mudge (with two more titles) et al. and just recently, Lynn Tylczak - new, forceful and different, all within the last five years - I certainly agree that we need more books dealing not so much with VE fundamentals as with later developments, more and varied techniques, new implementation areas, etc., to prove that VE is growing and changing for the better. Some examples are Tom Cook's VE work on a gall bladder operation, the Japanese method of "3-hour VE" in construction, new methods of weighted evaluation, etc. Certainly a large number of titles on such new aspects of VE would go a long way in increasing interest on the subject, retaining present members and attracting many more to SAVE.

While all this may take time, it is meanwhile possible for SAVE or better still, the international forum being created by Dr. Maramaldo to attempt to translate into English, some of the titles in French, German and Japanese languages or at least those chapters specially innovative and different. These could be made available to the international VE professionals at a cost that different countries can afford bearing in mind various factors.

As regards VE in education too, I had always held the view - in fact discussed with Larry Miles too - that VE does not belong as a full undergraduate course by itself, i.e., not in the same way as the basic engineering sciences such as civil, electrical, electronic, mechanical, etc. It can be one of the subjects but not the main course till the students acquire experience in a working environment, learn the existence of unnecessary costs in almost every area of human activity and therefore feel the need for techniques such as VE to identify and eliminate them. VE therefore correctly belongs in all extension courses and certainly for future managers going through business school; also advanced level postgraduate courses in VE particularly for those who have to implement it, who find the need for ways to expose and eliminate the unnecessary costs they suspect and therefore can afford to go back to school to learn how to. Here in the University of Delhi, VE is a compulsory subject for degrees in Industrial and Production Engineering and elective for other engineering courses but is not yet a part of the MBA syllabus. Of late, interest in VE is increasing in the Delhi School of Economics and the VE societies in India will attempt to sell the subject to the Faculty of Management Studies in different universities.

Lastly, for the new techniques such as TQM, QFD, etc. Yes, it is quite unnecessary for VE to be apprehensive of these (or other) new techniques because there is more direct (and auditable) evaluation of results achieved through a VE study rather than through many of these new fangled tools. Where some of them are actually more practical, clear and effective as, for instance, CAD, CAM, AI, etc., VE can and should exploit them to its/our advantage as indeed we have done with LCC. Repeatedly during the last 20 years, I have seen that VE can enhance the value of every other discipline while in turn, getting enriched itself by contact with them.

I hope there will be other responses to this article by Mr. Siorek and that the new ISAVE/USAVE (or whatever) will make a positive effort to ensure that VA not only has a place in the sun but will continue to shine brightly and shed light wherever it is needed most.

With kind regards,

S.S. Venkataramanan, CVS
SEND COMPLETED ORDER FORM TO:

SOCIETY OF AMERICAN VALUE ENGINEERS, INC.
60 Revere Drive, Northbrook, IL 60062

Please send to my attention the following items:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All prices subject to change without notice.
All prices include Book Rate postage and handling.
Interest will be charged at the rate of 1% per month on all accounts not paid within 30 days.
Add $20.00 per book for Overseas Airmail.

FULL PAYMENT IN U.S. FUNDS MUST ACCOMPANY ALL ORDERS

To qualify for Member rates, show Chapter Name:

- Visa  - MasterCard  Card number  Expires

Signature required for Visa and MasterCard.

Enclosed please find Check  Purchase Order  in the amount of $  

Name  
Title/Position  
Company  
Address  
City  State  Zip  
Office Telephone  

Society of American Value Engineers
60 Revere Drive
Northbrook, IL 60062

ADDRESS CORRECTION REQUESTED

Theodore C. Fowler
Fowler & Whitestone
5113 Weddington Drive
Dayton OH 45426