What is value engineering and Value Analysis?

**Value engineering (VE);** Retrieved from "http://en.wikipedia.org/wiki/Value_engineering"
It is a systematic method to improve the "value" of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.

Value engineering uses rational logic (a unique "how" - "why" questioning technique) and the analysis of function to identify relationships that increase value. It is considered a quantitative method similar to the scientific method, which focuses on hypothesis-conclusion approaches to test relationships, and operations research, which uses model building to identify predictive relationships.

It is an orderly and creative method to increase the value of an item. This “item” can be a product, a system, a process, a procedure, a plan, a machine, equipment, tool, a service or a method of working. Value Analysis, also called Functional Analysis was created by L.D. Miles.

The value of an item is how well the item does its function divided by the cost of the item (In value analysis value is not just another word for cost):

\[
\text{Value of an item} = \frac{\text{performance of its function}}{\text{cost}}
\]

An item that does its function better than another, has more value. Between two items that perform their function equally well, the one that costs less is more valuable.

The "performance of its function" could include that it is beautiful (where needed). Do not be surprised if as a result of value analysis the cost of an item is less than half of its previous cost.


Value engineering began at General Electric Co. during World War II. Because of the war, there were shortages of skilled labour, raw materials, and component parts. Lawrence Miles, Jerry Leftow, and Harry Erlicher at G.E. looked for acceptable substitutes. They noticed that these substitutions often reduced costs, improved the product, or both. What started out as an accident of necessity was turned into a systematic process. They called their technique “value analysis”.

**When to use it;** Retrieved from: http://creatingminds.org/tools/value_engineering.htm
- Use Value Analysis to analyze and understand the detail of specific situations.
- Use it to find a focus on key areas for innovation.
- Use it in reverse (called Value Engineering) to identify specific solutions to detail problems.

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It is particularly suited to physical and mechanical problems, but can also be used in other areas.
The Job Plan; Retrieved from; http://creatingminds.org/tools/value_engineering.htm
Value engineering is often done by systematically following a multi-stage job plan. Larry Miles’ original system was a six-step procedure which he called the "value analysis job plan." Others have varied the job plan to fit their constraints. Depending on the application, there may be four, five, six, or more stages. One modern version has the following eight steps:

1. Preparation
2. Information
3. Analysis
4. Creation
5. Evaluation
6. Development
7. Presentation
8. Follow-up

Four basic steps in the job plan are:
- Information gathering - This asks what the requirements are for the object. Function analysis, an important technique in value engineering, is usually done in this initial stage. It tries to determine what functions or performance characteristics are important. It asks questions like; What does the object do? What must it do? What should it do? What could it do? What must it not do?
- Alternative generation (creation) - In this stage value engineers ask; What are the various alternative ways of meeting requirements? What else will perform the desired function?
- Evaluation - In this stage all the alternatives are assessed by evaluating how well they meet the required functions and how great will the cost savings be.
- Presentation - In the final stage, the best alternative will be chosen and presented to the client for final decision.

How it works; Retrieved from; http://creatingminds.org/tools/value_engineering.htm
VE follows a structured thought process to evaluate options as follows.

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<th>Process</th>
<th>Action</th>
<th>Sub action</th>
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<tbody>
<tr>
<td>1 Gather information</td>
<td>1. What is being done now?</td>
<td>Who is doing it? What could it do? What must it not do?</td>
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<tr>
<td>2 Measure</td>
<td>2. How will the alternatives be measured?</td>
<td>What are the alternate ways of meeting requirements? What else can perform the desired function?</td>
</tr>
<tr>
<td>3 Analyze</td>
<td>3. What must be done?</td>
<td>What does it cost?</td>
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<tr>
<td>4 Generate</td>
<td>4. What else will do the job?</td>
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<tr>
<td>5 Evaluate</td>
<td>5. Which Ideas are the best?</td>
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<td></td>
<td>6. Develop and expand ideas</td>
<td>What are the impacts? What is the cost? What is the performance?</td>
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<tr>
<td></td>
<td>7. Present ideas</td>
<td>Sell alternatives</td>
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VA & The function of a product; Retrieved from: http://www.npd-solutions.com(va.html)

Since, the value analysis technique supported cost reduction activities by relating the cost of components to their function contributions.

Value analysis defines:

- A "basic function"
  It is anything that makes the product work or sells. A function that is defined as "basic" cannot change.
- Secondary functions
  It is also called "supporting functions", described the manner in which the basic function(s) were implemented. Secondary functions could be modified or eliminated to reduce product cost.

How to use it; Retrieved from: http://creatingminds.org/tools/value_engineering.htm

**Identify and prioritize functions**

- Identify the item to be analysed and the customers for whom it is produced.
- List the basic functions (the things for which the customer is paying). Note that there are usually very few basic functions.
- Identify the secondary functions by asking ‘How is this achieved?’ or ‘What other functions support the basic functions?’.
- Determine the relative importance of each function, preferably by asking a representative sample of customers (who will always surprise you with what they prefer).

**Analyze contributing functions**

- Find the components of the item being analyzed that are used to provide the key functions. Again, the question ‘How’ can come in very useful here.
- Measure the cost of each component as accurately as possible, including all material and production costs.
Seek improvements
Eliminate or reduce the cost of components that add little value, especially high-cost components.
Enhance the value added by components that contribute significantly to functions that are particularly important to customers.

Value Analysis (and its design partner, Value Engineering) is used to increase the value of products or services to all concerned by considering the function of individual items and the benefit of this function and balancing this against the costs incurred in delivering it. The task then becomes to increase the value or decrease the cost.

In analyzing a pen, the following table is used to connect components with the functions to which they contribute and hence identify areas of focus.
VALUE ANALYSIS AND FUNCTION

ANALYSIS SYSTEM TECHNIQUE; Retrieved from; http://www.npd-solutions.com/va.html

As VA progressed to larger and more complex products and systems, emphasis shifted to "upstream" product development activities where VA can be more effectively applied to a product before it reaches the production phase. However, as products have become more complex and sophisticated, the technique needed to be adapted to the "systems" approach that is involved in many products today. As a result, value analysis evolved into the "Function Analysis System Technique" (FAST) which is discussed later.

THE VALUE ANALYSIS METHOD

One objective of value analysis or function analysis, to improve value by reducing the cost-function relationship of a product, is achieved by eliminating or combining as many secondary functions as possible. Thus, the value analysis method is based on defining the functions of what to be accomplished and the cost to perform it.

Importance of defining function

Defining function provide the performance required to be accomplished. Usually, the function is defined in broad sense to have more opportunities for different thinking. This is done by describing what is to be accomplished with a verb and a noun.

- The verb answers the question, "What is to be done?" or, "What is it to do?" The verb defines the required action.
- The noun answers the question, "What is it being done to?" The noun tells what is acted upon.

Identifying the function by a verb-noun is not as simple a matter as it appears.

Also, identifying the function in the broadest possible term provides the greatest potential for divergent thinking because it gives the greatest freedom for creatively developing alternatives. A function should be identified as to what is to be accomplished by a solution and not how it is to be accomplished. How the function is identified determines the scope, or range of solutions that can be considered.

The functions designated as "basic" represent the operative function of the item or product and must be maintained and protected. Determining the basic function of single components can be relatively simple. By definition then, functions designated as "basic" will not change, but the way those functions are implemented is open to innovative speculation.

Importance of cost

As important as the basic function is to the success of any product, the cost to perform that function is inversely proportional to its importance. This is not an absolute rule, but rather an observation of the consumer products market.

Few people purchase consumer products based on performance or the lowest cost of basic functions alone. When purchasing a product it is assumed that the basic function is operative. The customer's attention is then directed to those visible secondary support functions, or product features, which determine the worth of the product.

From a product design point of view, products that are perceived to have high value first address the basic function's performance and stress the achievement of all of the performance attributes. Once the basic functions are satisfied, the designer's then address the secondary functions necessary to attract customers. Secondary functions are incorporated in the product as features to support and enhance the basic function and help sell the
product. The elimination of secondary functions that are not very important to the customer will reduce product cost and increase value without detracting from the worth of the product.

The cost contribution of the basic function does not, by itself, establish the value of the product. Few products are sold on the basis of their basic function alone. If this were so, the market for "no name" brands would be more popular than it is today. Although the cost contribution of the basic function is relatively small, its loss will cause the loss of the market value of the product.

VALUE ANALYSIS PROCESS

- **Define the problem and its scope** as the first step in the value analysis process.

- Then, **derive the functions of the product and its items**. These functions are classified into "basic" and "secondary" functions.

- **Prepare a Cost Function Matrix** or **Value Analysis Matrix** to identify the cost of providing each function by associating the function with a mechanism or component part of a product.
  - Identify Product functions with a high cost-function ratio as opportunities for further investigation and improvement. Improvement opportunities are then brainstormed, analyzed, and selected.
  - Use the objective of the Function Cost Matrix approach to draw the attention of the analysts away from the cost of components and focus their attention on the cost contribution of the functions.
  - The Function Cost Matrix displays the components of the product, and the cost of those components, along the left vertical side of the graph. The top horizontal legend contains the functions performed by those components. Each component is then examined to determine how many functions that component performs, and the cost contributions of those functions.
  - Estimate detailed cost as it becomes more important following function analysis, when evaluating value improvement proposals. The total cost and percent contribution of the functions of the item under study will guide the team, or analyst, in selecting which functions to select for value improvement analysis.

- A variation of the Function-Cost Matrix is the Value Analysis Matrix. This matrix was derived from the Quality Function Deployment (QFD) methodology. It is more powerful in two ways.
  - First, **it associates functions back to customer needs or requirements**. In doing this, it carries forward an importance rating to associate with these functions based on the original customer needs or requirements.
  - Functions are then related to mechanisms, the same as with the Function-Cost Matrix. Mechanisms are related to functions as either strongly, moderately or weakly supporting the given function. This relationship is noted with the standard QFD relationship symbols. The associated weighting factor is multiplied by customer or function importance and each columns value is added. These totals are normalized to calculate each mechanism's relative weight in satisfying the designated functions.
  - This is where the second difference with the Function-Cost Matrix arises. This mechanism **weight can then be used as the basis to allocate the overall item or product cost**. The mechanism target costs can be compared with the actual or estimated costs to see where costs are out of line with the value of that mechanism as derived from customer requirements and function analysis.
FUNCTION ANALYSIS SYSTEM TECHNIQUE [FAST]

It is an evolution of the value analysis process created by Charles Bytheway. He set of original questions for FAST includes the following:

1. What subject or problem would you like to address?
2. What are you really trying to do when you?
3. What higher level function has caused to come into being?
4. Why is it necessary to?
5. How is actually accomplished or how is it proposed to be accomplished?
6. Does the method selected to cause any supporting functions to come into being?
7. If you did not have to perform, would you still have to perform the other supporting functions?
8. When you, do apparent dependent functions come into existence as a result of the current design?
9. What or who actually?

FAST permits people with different technical backgrounds to effectively communicate and resolve issues that require multi-disciplined considerations.

FAST builds upon VA by linking the simply expressed, verb-noun functions to describe complex systems.

FAST is not an end product or result, but rather a beginning. It describes the item or system under study and causes the team to think through the functions that the item or system performs, forming the basis for a wide variety of subsequent approaches and analysis techniques. FAST contributes significantly to perhaps the most important phase of value engineering: function analysis. FAST is a creative stimulus to explore innovative avenues for performing functions.

The FAST diagram or model is an excellent communications vehicle. Using the verb-noun rules in function analysis creates a common language, crossing all disciplines and technologies. It allows multi-disciplined team members to contribute equally and communicate with one another while addressing the problem objectively without bias or preconceived conclusions.

With FAST, there is no right or wrong model or result. The problem should be structured until the product development team members are satisfied that the real problem is identified. After agreeing on the problem statement, the single most important output of the multi-disciplined team engaged in developing a FAST model is consensus. Since the team has been charged with the responsibility of resolving the assigned problem, it is their interpretation of the FAST model that reflects the problem statement that's important. The team members must discuss and reconfigure the FAST model until consensus is reached and all participating team members are satisfied that their concerns are expressed in the model. Once consensus has been achieved, the FAST model is complete and the team can move on to the next creative phase.

FAST differs from value analysis in the following:

- Use of intuitive logic to determine and test function dependencies and the graphical display of the system in a function dependency diagram or model.
- Analyzing a system as a complete unit, rather than analyzing the components of a system.

When studying systems it becomes apparent that functions do not operate in a random or independent fashion. A system exists because functions form dependency links with other functions, just as components form a dependency link with other components to make the system work.

The importance of the FAST approach is that it graphically displays function dependencies and creates a process to study function links while exploring options to develop improved systems.
There are normally two types of FAST diagrams, the technical FAST diagram and the customer FAST diagram. A technical FAST diagram is used to understand the technical aspects of a specific portion of a total product. A customer FAST diagram focuses on the aspects of a product that the customer cares about and does not delve into the technicalities, mechanics or physics of the product. A customer FAST diagram is usually applied to a total product.

**CREATING A FAST MODEL**

**a) Develop FAST Diagram**

The FAST model has a horizontal directional orientation described as the HOW-WHY dimension. This dimension is described in this manner because HOW and WHY questions are asked to structure the logic of the system's functions.

- Start with a function, and ask **HOW** that function is performed to develop a more specific approach. This line of questioning and thinking is read from left to right.
- Abstract the problem to a higher level, and ask **WHY** that function is performed. This line of logic is read from right to left.

The essential logic associated with the FAST HOW-WHY directional orientation when undertaking any task is:

- Start with the goals of the task, and then
- Explore methods to achieve the goals.

Addressing any function on the FAST model can be as follow:

- The question **WHY** is answered by the function on the left which expresses the goal of that function.
- The question **HOW** is answered by the function on the right, which is a method to perform that function being addressed.

A systems diagram starts at the beginning of the system and ends with its goal. A FAST model, reading from left to right, starts with the goal, and ends at the beginning of the "system" that will achieve that goal.

Second, changing a function on the HOW-WHY path affects all of the functions to the right of that function. This is a domino effect that only goes one way, from left to right. Starting with any place on the FAST model, if a function is changed the goals are still valid (functions to the left), but the method to accomplish that function, and all other functions on the right, are affected.

Finally, building the model in the HOW direction, or function justification, will focus the team's attention on each function element of the model. Whereas, reversing the FAST model and building it in its system orientation will cause the team to leap over individual functions and focus on the system, leaving function "gaps" in the system. A good rule to remember in constructing a FAST Model is to build in the HOW direction and test the logic in the WHY direction.

The vertical orientation of the FAST model is described as the **WHEN** direction. This is not part of the intuitive logic process, but it supplements intuitive thinking. **WHEN** is not a time orientation, but indicates cause and effect.

Scope lines represent the boundaries of the study and are shown as two vertical lines on the FAST model. The scope lines bound the "scope of the study", or that aspect of the problem with which the study team is concerned.

- The left scope line determines the basic function(s) of the study. The basic functions will always be the first function(s) to the immediate right of the left scope line.
• The right scope line identifies the beginning of the study and separates the input function(s) from the scope of the study.

The objective or goal of the study is called the "Highest Order Function", located to the left of the basic function(s) and outside of the left scope line. Any function to the left of another function is a "higher order function". Functions to the right and outside of the right scope line represent the input side that "turn on" or initiate the subject under study and are known as lowest order functions. Any function to the right of another function is a "lower order" function and represents a method selected to carry out the function being addressed.

Those function(s) to the immediate right of the left scope line represent the purpose or mission of the product or process under study and are called Basic Function(s). Once determined, the basic function will not change. If the basic function fails, the product or process will lose its market value.

All functions to the right of the basic function(s) portray the conceptual approach selected to satisfy the basic function. The concept describes the method being considered, or elected, to achieve the basic function(s). The concept can represent either the current conditions (as is) or proposed approach (to be). As a general rule, it is best to create a "to be" rather than an "as is" FAST Model, even if the assignment is to improve an existing product. This approach will give the product development team members an opportunity to compare the "ideal" to the "current" and help resolve how to implement the differences. Working from an "as is" model will restrict the team's attention to incremental improvement opportunities. An "as is" model is useful for tracing the symptoms of a problem to its root cause, and exploring ways to resolve the problem, because of the dependent relationship of functions that form the FAST model.

Any function on the HOW-WHY logic path is a logic path function. If the functions along the WHY direction lead into the basic function(s), than they are located on the major logic path. If the WHY path does not lead directly to the basic function, it is a minor logic path. Changing a function on the major logic path will alter or destroy the way the basic function is performed. Changing a function on a minor logic path will disturb an independent (supporting) function that enhances the basic function. Supporting functions are usually secondary and exist to achieve the performance levels specified in the objectives or specifications of the basic functions or because a particular approach was chosen to implement the basic function(s).

Independent functions describe an enhancement or control of a function located on the logic path. They do not depend on another function or method selected to perform that function. Independent functions are located above the logic path function(s), and are considered secondary, with respect to the scope, nature, level of the problem, and its logic path. An example of a FAST Diagram for a pencil is shown below.
b) Dimensioning FAST Model
The next step in the process is to dimension the FAST model or to associate information to its functions. FAST dimensions include, but are not limited to: responsibility, budgets, allocated target costs, estimated costs, actual costs, subsystem groupings, placing inspection and test points, manufacturing processes, positioning design reviews, and others. There are many ways to dimension a FAST model. The two popular ways are called Clustering Functions and the Sensitivity Matrix.

Clustering functions involves drawing boundaries with dotted lines around groups of functions to configure subsystems. Clustering functions is a good way to illustrates cost reduction targets and assign design-to-cost targets to new design concepts. For cost reduction, a team would develop an "as is" product FAST model, cluster the functions into subsystems, allocate product cost by clustered functions, and assign target costs. During the process of creating the model, customer sensitivity functions can be identified as well as opportunities for significant cost improvements in design and production.

Following the completion of the model, the subsystems can be divided among product development teams assigned to achieve the target cost reductions. The teams can then select cost sensitive sub-systems and expand them by moving that segment of the model to a lower level of abstraction. This exposes the detail components of that assembly and their function/cost contributions.

INTEGRATING QFD WITH FAST
A powerful analysis method is created when FAST is used in conjunction with QFD. QFD enables the uses of the Value Analysis Matrix. An example of a value analysis matrix for the pencil example is shown below.
The steps for using these two methodologies are as follows:

1. Capture customer requirements and perform QFD product planning with the product planning matrix. Translate customer needs into directly into verb-noun functions or use a second matrix to translate technical characteristics into verb-noun functions.

2. Prepare a FAST diagram and develop the product concept in conjunction with the QFD concept selection matrix. Review the verb-noun functions in the QFD matrix and assure that they are included in the FAST diagram. Revise verb-noun function descriptions if necessary to assure consistency between the QFD matrix and the FAST diagram.

3. Dimension the system in the FAST diagram into subsystems/assemblies/parts. These are generically referred to as mechanisms.

4. Develop value analysis matrix at system level. The "what's" or system requirements/function in the value analysis matrix are derived from either a customer (vs. technical) FAST diagram or by selecting those function statements that correspond to the customer needs or technical characteristics in the product planning matrix. The importance rating is derived from the product planning matrix as well.

5. Complete the value analysis matrix by relating the mechanisms to the customer requirements/functions and calculate the associated weight. Summarize the column weights and normalize to create mechanism weights. Allocate the target cost based on the mechanism weights. This represents the value to the customer based on the customer importance. Compare with either estimated costs based on the product concept or actual costs if available.

6. Identify high cost to value mechanisms / subsystems by comparing the mechanism target costs to the mechanism estimated/actual costs.

A product or system such as an automobile contains a great many components and would result in an extremely complex FAST model. The complexity of the process is not governed by the number of components in a product, but the level of abstraction selected to perform the analysis. With an automobile, a high level of abstraction could contain the major subsystems as the components under study, such as: the power train, chassis, electrical system, passenger compartment, etc. The result of the FAST model and supporting cost analysis might then focus the team's attention on the power train for further analysis. Moving to a lower level of abstraction, the power train could then be divided into its components (engine, transmission, drive shaft, etc.) for a more detailed analysis.
In other words, the concept of decomposition is applied to a FAST model. The initial FAST model will stay at a high level of abstraction. Starting at a higher level of abstraction allows for uncluttered macro analysis of the overall problem until those key functions can be found, isolated, and the key issues identified. If a function is identified for further study, we note that with a "^" below the function box. A supporting FAST diagram is then created for that subsystem function. This process of decomposition or moving to lower levels of abstraction could be carried down several levels if appropriate.

Once high cost to value mechanisms is identified in the initial system value analysis matrix, the next step is to focus more attention on those mechanisms and associated functions. Dimensioning groups the functions together into those associated with a particular subsystem, assembly or part. The FAST diagram can be expanded into a lower level of abstraction in the area under investigation. The steps involved are as follows:

1. Use QFD to translate higher-level customer needs to subsystem technical characteristics.
2. Create FAST diagram at lower level of abstraction for targeted mechanism/subsystem.
3. Prepare a FAST diagram & develop the product concept in conjunction with the QFD concept selection matrix.
4. Dimension the system in the FAST diagram into assemblies/parts or identify the assemblies/parts needed to perform the given function.
5. Develop value analysis matrix at a lower level of abstraction for the targeted subsystem. The "what's" or system requirements/function in the value analysis matrix are derived from either a customer (vs. technical) FAST diagram or by selecting those function statements that correspond to the customer needs or technical characteristics in the subsystem planning matrix.
6. Complete the value analysis matrix and identify high cost to value mechanisms by comparing the mechanism target costs to the mechanism estimated/actual costs.

**VALUE IMPROVEMENT PROCESS**

Performing value analysis or producing the FAST model and analyzing functions with the value analysis matrix are only the first steps in the process. The real work begins with brainstorming, developing and analyzing potential improvements in the product. These subsequent steps are supported by:

- The QFD Concept Selection Matrix is a powerful tool to evaluate various concept and design alternatives based on a set of weighted criteria that ultimately tie back to customer needs.
- Benchmarking competitors and other similar products helps to see new ways functions can be performed and breaks down some of the not-invented-here paradigms.
- Product cost and life cycle cost models support the estimating of cost for the Function-Cost and Value Analysis Matrices and aid in the evaluation of various product concepts.
- Technology evaluation is leads us to new ways that basic functions can be performed in a better or less costly way. Concept development should involve people with a knowledge of new technology development and an open mind to identify how this technology might relate to product functions that need to be performed. Methods such as the theory of inventive problem solving or TRIZ are useful in this regard.
- Design for Manufacturability/Assembly principles provide guidance on how to better design components and assemblies that are more manufactureable and, as a result, are lower in cost.

Value Analysis or Function Analysis provide the methods to identify the problem and to begin to define the functions that need to be performed. As we proceed in developing a FAST model, implicit in this process is developing a concept of operation for the product which is represented by all of the lower order functions in a FAST diagram.
Concept alternatives will be developed through brainstorming, benchmarking other products performing similar functions, and surveying and applying new technology. Since multiple concepts need to be evaluated, we want to use a higher level of abstraction for the FAST model to provide us with the greatest flexibility and a minimum level of effort. Trade studies and technical analysis will be performed to evaluate various product concepts. A concept selection matrix is a good tool to summarize a variety of different data and support making a decision about the preferred concept.

All of these steps may be iterative as a preferred concept evolves and gets more fully developed. In addition, there should be a thorough evaluation of whether all functions are needed or if there is a different way of accomplishing a function as the concept is developed to a lower level of abstraction. When a Function Cost or Value Analysis Matrix is prepared, functions that are out of balance with their worth are identified, further challenging the team to explore different approaches.

SUMMARY

Value analysis and its more robust cousin, Function Analysis System Technique, are important analysis tools. These methodologies lead to improved product designs and lower costs by:

- Providing a method of communication within a product development team and achieving team consensus
- Facilitating flexibility in thinking and exploring multiple concepts
- Focusing on essential functions to fulfill product requirements
- Identifying high cost functions to explore improvements

References

1. ^Value Methodology Standard
2. ^Text of Law Requiring Value Engineering in Executive Agencies
4. ^SAVE International - Value Engineering, Value Analysis, Value Management and Value Methodology

Further reading

- "Value Engineering - Concepts, Techniques and Applications by Anil Kumar Mukhopadhyaya"
- "Value Engineering Mastermind - From Concept to Value Engineering Certification by Anil Kumar Mukhopadhyaya"
• "Value Optimization for Project and Performance Management by Robert B. Stewart, CVS-Life, FSAVE, PMP"

External links
• Lawrence D. Miles Value Foundation
• Lawrence D. Miles Value Engineering Reference Center: Wendt Library
• SAVE International - Value engineering society
• wertanalyse.com - Many links regarding VE organisations and publications
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