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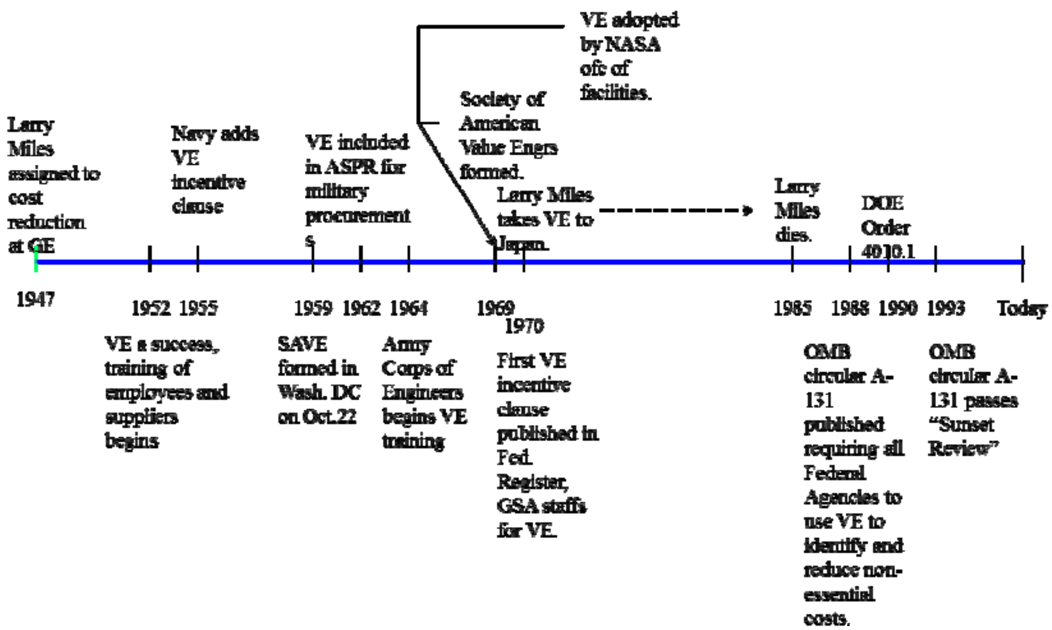
HISTORY OF VALUE ANALYSIS

The value analysis methodology was started in the late 1940's by Lawrence D. Miles Lawrence D. Miles started the value analysis methodology in the late 1940's while working in the purchasing department at General Electric. Faced with a lack of strategic materials, the company asked Miles to identify new materials to reduce costs. He, then, gradually put into place a rigorous work plan which yielded reductions of 40 %.

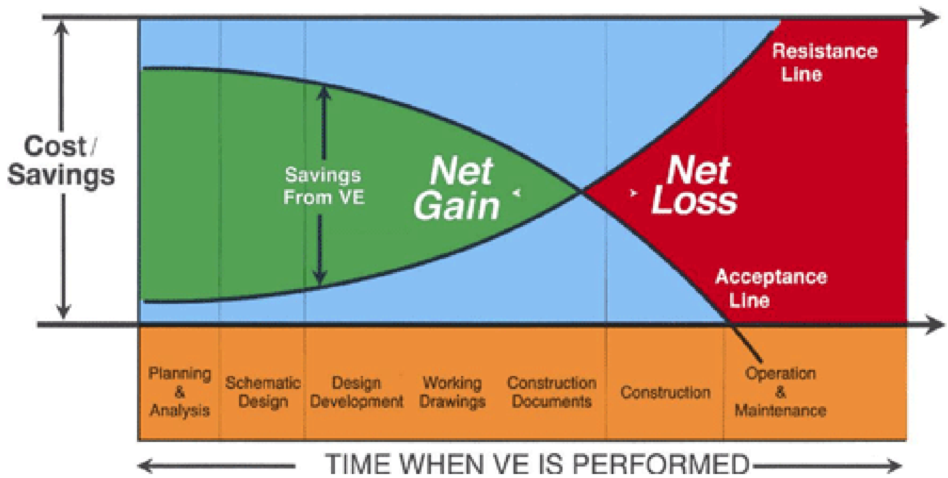


PRINCIPLES OF THE METHODOLOGY

Value analysis is a systematic and creative method to improve competitiveness. It is aimed at satisfying user needs by means of a specific procedure for invention (or modification) which is functional (the purpose), economic (what it costs), and multidisciplinary (how).

In other words, value analysis identifies the activities necessary for a process to develop a product or service, and finds the most economic way to accomplish it. This method permits the effective identification of that part of process cost which does not contribute to ensure process quality.

The improvement of a process must never put into jeopardy the quality of a product, especially in terms of the safety and reliability of a product. Value analysis can make an existing process profitable or optimize the effectiveness and the profitability of a process at the time of its design.



Potential saving from VE study

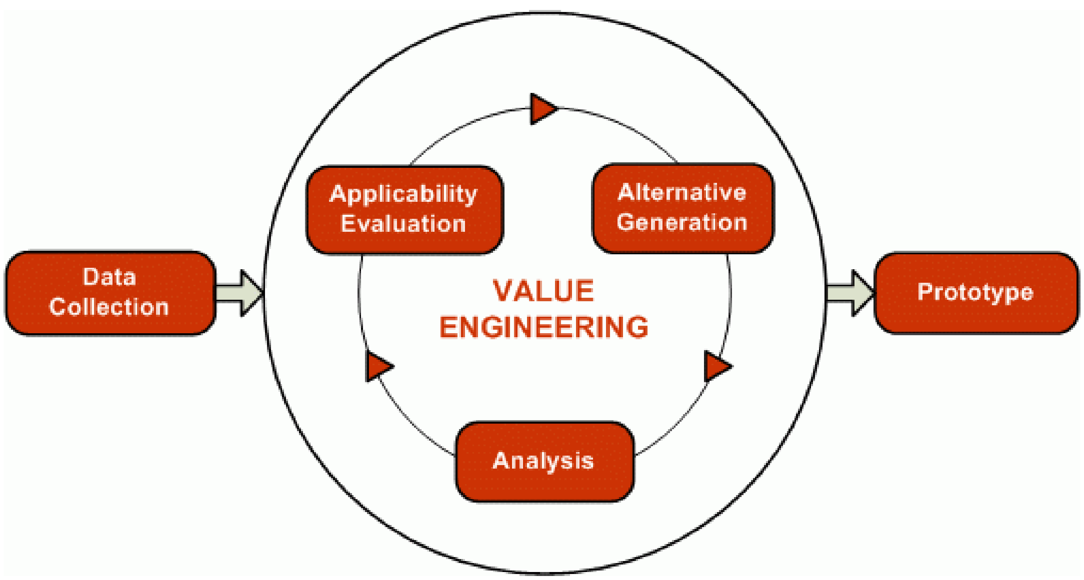
AREAS OF APPLICATION

Value Analysis has been successful in several domains:

- Defense
- Automotive
- Aeronautical
- Software development
- Water treatment
- Civil engineering
- Etc...

It has also proven very effective in "soft" areas such as:

- Client services
- Work processes
- Information Systems
- Organizational development
- Etc...



VALUE METHODOLOGY APPLICABILITY

A. The Value Methodology can be applied wherever cost and/or performance improvement is desired. That improvement can be measured in terms of monetary; aspects and/or other critical factors such as productivity, quality, time, energy, environmental impact, and durability. VM can beneficially be applied to virtually all areas of human endeavor

B. The Value Methodology is applicable to hardware, building, or other construction projects, and to "soft" areas such as manufacturing and construction processes, health care and environment services programming management systems and organization structure. The pre-study efforts for these "soft" types of projects utilizes standard industrial engineering techniques such as flow charting, yield analysis, and value added task analysis to gather essential data.

C. For civil, commercial, and military engineering works such as buildings highways, factory construction and water / sewage treatment plants, which tend to be one time applications, VM is applied on a project-to-project basis.

Since these are one – time capital projects, VM must be applied as early in the design cycle as feasible to achieve maximum benefits. Changes or redirection of design can be accomplished without extensive redesign, large implementation cost, schedule impacts Typically for large construction projects, specific value studies are conducted during the schematic stage, and then again at the design development (up to 45%) stage. Additional value studies may be conducted during the construction or build phase.

D. For large or unique Products and systems such as military electronics or specially designed capital equipment, VM is applied during the design cycle to assure meeting of goals and objectives. Typically a formalized value study is performed after preliminary design approval but before release to the build / manufacture cycle. VM may also be applied during the build / manufacture cycle to assure that the latest materials and technology are utilized.

E. VM can also be applied during planning stages and for project / program management control by developing function models with assigned cost and performance parameters. If Specific functions show trends toward beyond control limits, value studies are performed to assure the function's performance remains within the control limits.

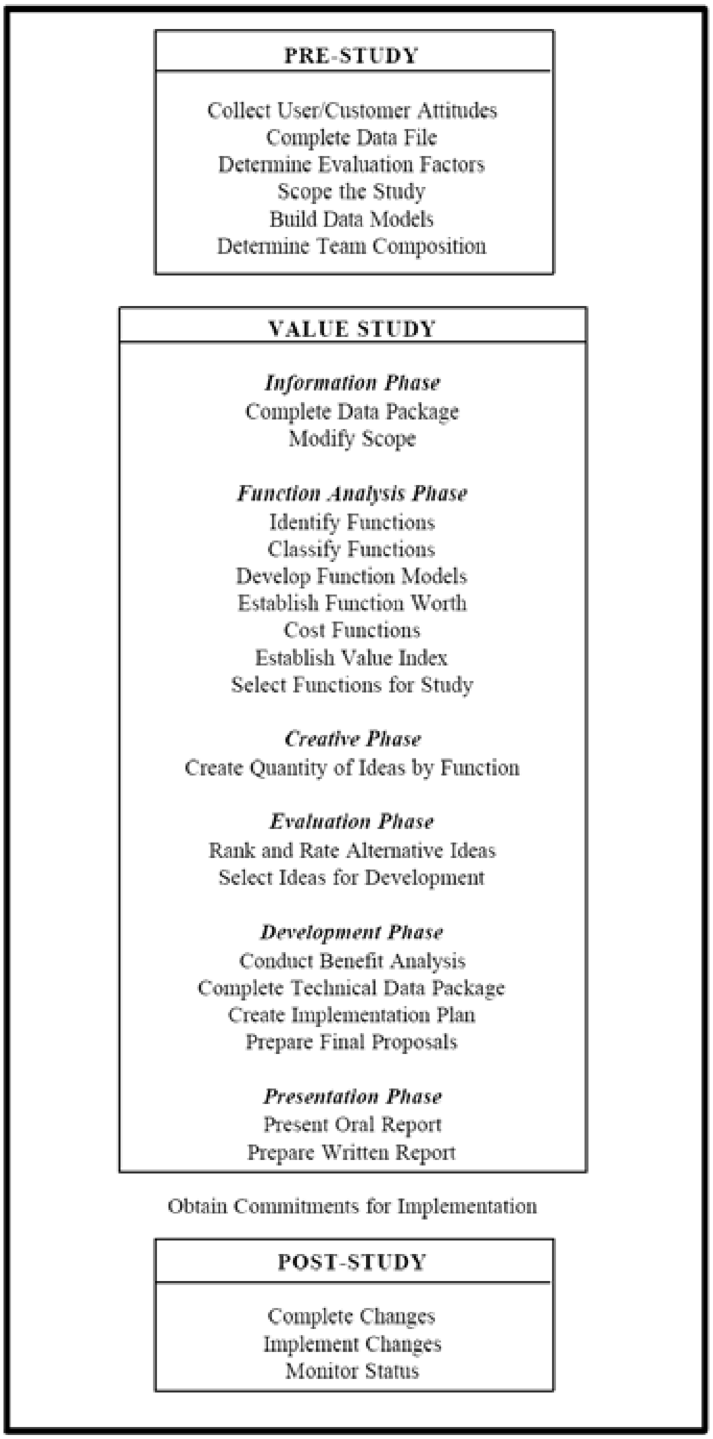


Figure 1: The VM Job Plan

The VM Job Plan covers three major periods of activity: Pre-Study, the Value Study, and Post-Study. All phases and steps are performed sequentially. As a value study progresses new data and information may cause the study team to return to earlier phases or steps within a phase on an iterative basis. Conversely, phases or steps within phases are not skipped.

I. PRE-STUDY

Preparation tasks involve six areas: Collecting/ defining User / Customer wants and needs, gathering a complete data file of the project, determining evaluation factors, scoping the specific study, building appropriate models and determining the team composition.

A. Collect User / Customer Attitudes

The User/Customer attitudes are compiled via an in-house focus group and/or external market surveys. The objectives are to:

1. Determine the prime buying influence.
2. Define and rate the importance of features and characteristics of the product or project.
3. Determine and rate the seriousness of user-perceived faults and complaints of the product or project.
4. Compare the product or project with competition or through direct analogy with similar products or project.

For first time projects such as a new product or new construction, the analysis may be tied to project goals and objectives. The results of this task will be used to establish value mismatches in the information Phase.

B. Gather a Complete Data File

There are both Primary and Secondary sources of information. Primary sources are of two varieties: people and documentation. People Sources include marketing (or the user), original designer, architect, cost or estimating group, maintenance or field service, the builders (manufacturing), constructors, or systems designers), and consultants. Documentation sources include drawings, project specifications, bid documents and project plans.

Secondary sources include suppliers of similar products, literature such as engineering and design standards, regulations, test results, failure reports, and trade journals. Another major source is like or similar projects. Quantitative data is desired

Another secondary source is a Site visitation by the value study team. "Site" includes actual construction location, manufacturing line, or office location for a new/improved system. If the actual "site "not available, facilities with comparable functions and activities may prove to be a valuable source of usable information.

C. Determine Evaluation Factors

The team, as an important step in the process. Determines what will be the criteria for evaluation of ideas and the relative importance of each criterion to final recommendations and decisions for change. These criteria and their importance are discussed with the user /customer and management and concurrence obtained

D. Scope the Study

The team develops the scope statement for the specific study. This statement defines the limits of the study based on the data-gathering tasks. The limits are the starting point and the completion point of the study. Just as important, the scope statement defines what is not included in the study. The scope statement must be verified by the study sponsor.

E. Build Models

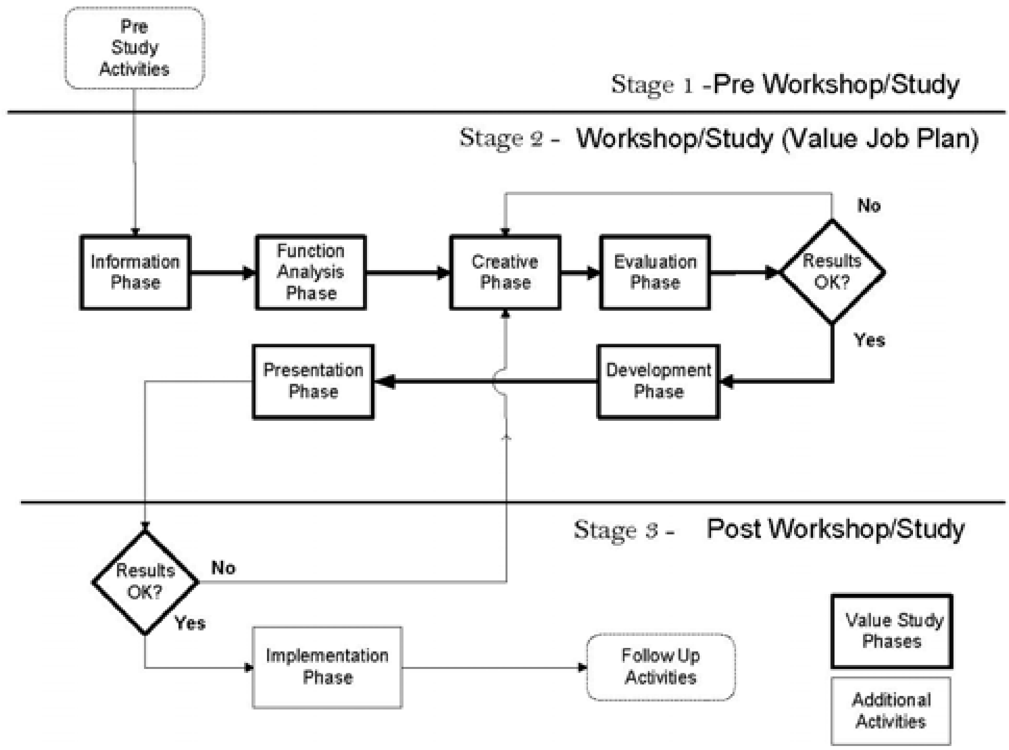
Based on the completion and agreement of the scope statement, the team may compile models for further understanding of the study. These include such models as Cost, Time, Energy, Flow Charts, and Distribution, as appropriate for each study.

F. Determine Team Composition, Wrap-Up

The Value Study Team Leader confirms the actual study schedule, location and need for any support personnel. The study team composition is reviewed to assure all necessary customers, technical, and management areas are represented. The Team Leader assigns data gathering tasks to team members so all pertinent data will be available for the study.

II. THE VALUE STUDY

The value study is where the primary Value Methodology is applied. The effort is composed of six phases. Information, Function analysis, creativity, Evaluation, Development, and Presentation.



A. Information Phase

The Objective of the Information Phase is to complete the value study data package started in the Pre-Study work. If not done during the Pre-Study activities, the project sponsor and / or designer brief the value study team, providing an opportunity for the team to ask questions based on their data research. If a "site" visitation was not possible during Pre-Study, .It should be completed during this phase.

The study team agrees to the most appropriate targets for improvement such as value, cost, performance, and schedule factors. These are reviewed with appropriate management, such as the project manager, value study' sponsor, and designer, to obtain concurrence.

Finally, the scope statement is reviewed for any adjustments due to additional information gathered during the information Phase.

B. Function Analysis Phase

Function definition and analysis is the heart of Value Methodology. It is the primary activity that separates Value Methodology from all other "improvement" practices. The objective of this phase is to develop the most beneficial areas for continuing study.

FUNCTION ANALYSIS WORKSHEET

PROJECT: Hospital
ITEM: COMPLETE LIST
BASIC FUNCTION: Treat Patients

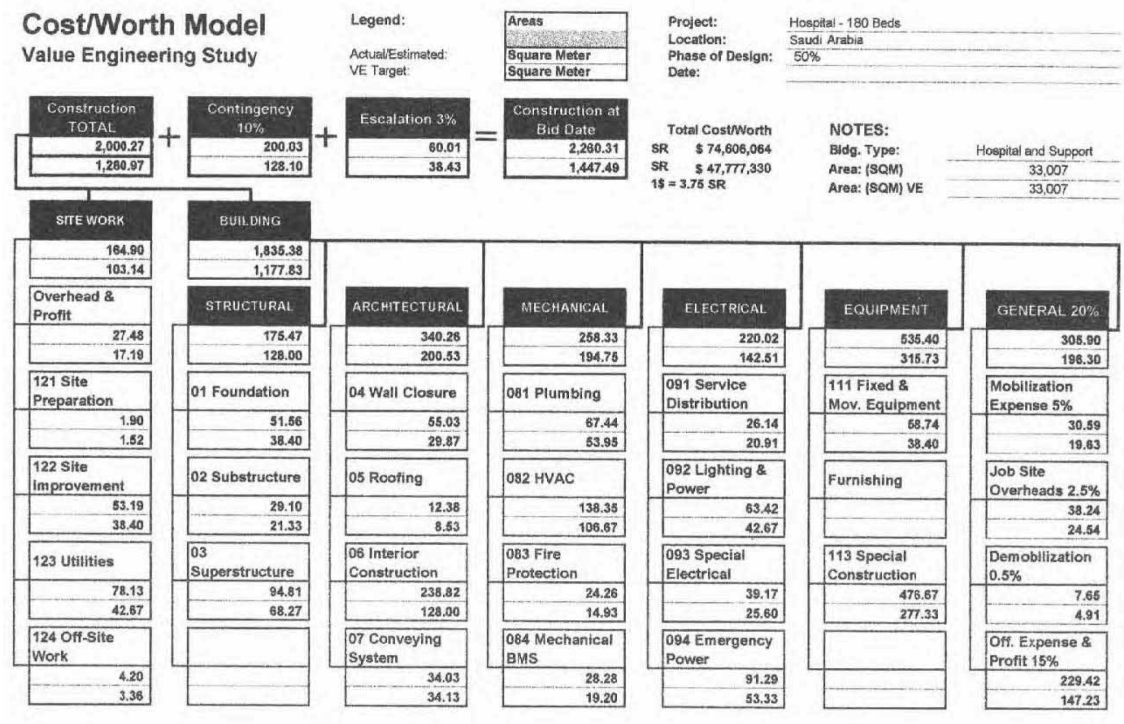
COMPONENT DESCRIPTION	FUNCTION (VERB-NOUN)	KIND	COST	WORTH	COST/ WORTH	COMMENTS
B = Basic Function	S = Secondary Function	RS = Required Secondary Function				
SITE WORK						
Overhead & Profit	Manage Work	RS	907,116	567,367	1.60	Reduce percentage
121 Site Preparation	Prepare Site	RS	62,667	50,133	1.25	
122 Site Improvement	Improve Site	RS	1,755,580	1,267,469	1.39	Relocate structures
123 Site Utilities	Supply Utilities	B	2,578,667	1,408,299	1.83	Revise layout
124 Off-Site Work	Supply Utilities	B	138.667	110.933	1.25	
TOTAL			**5,442,696**	**3,404,201**	***1.60***	
STRUCTURAL						
01 Foundation	Support Load	B	1,701,845	1,267,469	1.34	Eliminate water level
02 Substructure	Support Load	RS	960,557	704,149	1.36	Move substructure to grade level
03 Superstructure	Support Load	B	3,129,387	2,253,278	1.39	Simplify structural system
TOTAL			**5,791,789**	**4,224,896**	**1.37**	
ARCHITECTURAL						
04 Wall Closure	Enclose Space	B	1,816,320	985,809	1.84	Replace granite/marble with precast elements
05 Roofing	Protect Building	RS	408,787	281,660	1.45	Reduce space
06 Interior Const.	Finish and Divide Space	B	7,882,597	4,224,896	1.87	Change wall construction from gypsum to CMU
07 Conveying System	Transport Weight	B	1,123,200	1,126,639	1.00	
TOTAL			**11,230,904**	**6.61 9,004**	**1.70**	
MECHANICAL						
081 Plumbing	Service Building	B	2,225,867	1,780,693	1.25	Consolidate waste and soil line
082 HVAC	Condition Space	B	4,566,667	3,520,747	1.30	Use unitary cooling
083 Fire Protection	Protect Building and People	RS	800,787	492,905	1.62	Limit sprinklers at public areas
084 Special Mechanical	Control System	RS	933,333	633,734	1.47	
TOTAL			**8,526,653**	6,428,079	**1.33**	

Facility Types - Cost Per Building Gross Square Foot*

	Corp. Office $/GSF		Financial $/GSF		Medical $/GSF		University $/GSF		Research $/GSF		Industrial $/GSF	
INITIAL COSTS:	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Initial Project Cost	126.36	228.80	146.30	255.20	224.25	462.00	147.40	264.75	194.35	495.00	90.85	199.00
Construction Cost (incl. Site)	95.00	130.00	110.00	145.00	150.00	210.00	110.00	150.00	130.00	225.00	70.00	100.00
Design Fees	4.28	7.80	4.95	8.70	10.50	21.00	6.05	9.75	9.10	22.50	2.45	5.00
Construction Administration	1.90	5.20	220	5.80	3.00	8.40	2.20	6.00	2.60	9.00	1.05	3.00
Site	4.75	19.50	5.50	21.75	7.50	31.50	5.50	22.50	6.50	33.75	2.10	10.00
Reservation Costs:												
Const. Contingency	4.28	7.80	4.95	8.70	6.75	12.60	4.95	9.00	5.85	13.50	3.15	6.00
Furnishings/Equip.	9.50	26.00	11.00	29.00	30.00	105.00	11.00	30.00	26.00	112.50	7.00	50.00
Interim Financing	5.70	19.50	6.60	21.75	9.00	31.50	6.60	22.50	7.80	33.75	4.20	15.00
Other	0.95	13.00	1.10	14.50	7.50	42.00	1.10	15.00	6.50	45.00	0.70	10.00
ANNUAL COSTS:	$/GSF/Year		$/GSF/Year		$/GSF/Year		$/GSF/Year		$/GSF/Year		$/GSF/Year	
Energy/Fuel Cost	1.48	2.75	1.57	2.57	2.06	3.28	1.53	2.52	1.72	2.73	1.75	5.00
Maintenance, Repair & Custodial	2.24	5.23	1.94	3.92	2.65	5.53	1.66	3.48	2.40	5.28	1.85	4.15
Cleaning (Custodial)	0.88	1.72	0.80	1.48	1.07	2.57	0.70	1.30	0.99	2.39	0.60	1.40
Repirs & Maintenance	1.07	2.65	0.96	1.90	1.20	2.18	0.80	1.70	1.12	2.08	1.05	2.00
Roads & Ground Maintenance	0.29	0.86	0.18	0.54	0.38	0.78	0.16	0.48	029	0.86	0.20	0.75
Alterations and Replacements	2.85	6.50	3.30	7.25	4.50	18.90	3.30	7.50	3.90	20.25	2.10	9.00
Alterations	0.95	2.60	1.10	2.90	1.50	10.50	1.10	3.00	1.30	11.25	0.70	5.00
Replacements	1.90	3.90	2.20	4.35	3.00	8.40	220	4.50	2.60	9.00	1.40	4.00
Associated Costs	86.51	153.74	88.32	157.20	120.21	280.69	30.94	68.03	113.90	359.80	42.73	177.53
Administrative (Bldg. Mgmt.)	0.44	1.04	0.37	0.92	0.48	0.98	0.30	0.70	0.45	1.10	0.40	0.90
Interest (Debt Service)	8.84	22.88	1024	25.52	15.70	46.20	10.32	26.48	9.80	49.50	9.80	19.90
Staffing (Functional use)	75.00	125.00	75.00	125.00	100.00	225.00	20.00	40.00	100.00	300.00	30.00	150.00
Denial-oi-Use Costs	(Lost Income)		(Lost Income)		(Lost Income)		(Lost Income)		(Lost Income)		(Lost Income)	
Other Costs:												
Security	0.07	0.22	0.23	0.68	0.19	0.39	0.04	0.12	0.23	0.68	0.20	0.70
Real Estate Taxes	1.90	3.90	220	4.35	3.00	6.30	N/A	N/A	2.60	6.75	1.40	3.00
Water & Sewer	0.16	0.31	0.17	029	0.69	1.09	0.17	0.28	0.69	1.09	0.86	2.73
Fire Insurance	0.10	0.39	0.11	0.44	0.15	0.63	0.11	0.45	0.13	0.68	0.07	0.30

The team performs the following steps:

1. Identify and define both work and sell functions of the product, project, or process under study using active verbs and measurable nouns. This is often referred to as Random Function Definition.
2. Classify the functions as basic or secondary
3. Expand the functions identified in step I (optional)
4. Build a function Model - Function hierarchy / logic or Function Analysis System Technique *(FAST)* diagram.
5. Assign cost and / or other measurement criteria to functions
6. Establish worth of functions by assigning the Previously established User/customer attitudes to the functions
7. Compare cost to worth of functions to establish the best Opportunities for improvement
8. Assess functions for performance / schedule Considerations
9. Select functions for Continued analysis
10. Refine study scope



Cost/Worth Model
Value Engineering Study
Legend:
Actual/Estimated:
VE Target:
Areas
Square Meter
Square Meter
Project:
Location:
Phase of Design:
Date:
Hospital - 180 Beds
Saudi Arabia
50%
Construction TOTAL
2,000.27
1,280.97
Contingency 10%
200.03
128.10
Escalation 3%
60.01
38.43
Construction at Bid Date
2,260.31
1,447.49
Total Cost/Worth
SR $ 74,606,064
SR $ 47,777,330
1$ = 3.75 SR
NOTES:
Bldg. Type:
Area: (SQM)
Area: (SQM) VE
Hospital and Support
33,007
33,007
SITE WORK
164.90
103.14
BUILDING
1,835.38
1,177.83
Overhead & Profit
27.48
17.19
121 Site Preparation
1.90
1.52
122 Site Improvement
53.19
38.40
123 Utilities
78.13
42.67
124 Off-Site Work
4.20
3.36
STRUCTURAL
175.47
128.00
01 Foundation
51.56
38.40
02 Substructure
29.10
21.33
03 Superstructure
94.81
68.27
ARCHITECTURAL
340.26
200.53
04 Wall Closure
55.03
29.87
05 Roofing
12.38
8.53
06 Interior Construction
238.82
128.00
07 Conveying System
34.03
34.13
MECHANICAL
258.33
194.75
081 Plumbing
67.44
53.95
082 HVAC
138.35
106.67
083 Fire Protection
24.26
14.93
084 Mechanical BMS
28.28
19.20
ELECTRICAL
220.02
142.51
091 Service Distribution
26.14
20.91
092 Lighting & Power
63.42
42.67
093 Special Electrical
39.17
25.60
094 Emergency Power
91.29
53.33
EQUIPMENT
535.40
315.73
111 Fixed & Mov. Equipment
58.74
38.40
Furnishing
113 Special Construction
476.67
277.33
GENERAL 20%
305.90
196.30
Mobilization Expense 5%
30.59
19.63
Job Site Overheads 2.5%
38.24
24.54
Demobilization 0.5%
7.65
4.91
Off. Expense & Profit 15%
229.42
147.23

FUNCTION: DEFINITION AND ANALYSIS

Abstract:

The primary objective of the Function Analysis Phase is to determine the most beneficial areas for value improvement, while unnecessary cost removal has been the traditional target for value studies, it is important to emphasize that more frequently today value studies are conducted to improve a product or service's performance such as time or quality without increasing cost.

I. Identifying and Defining Functions:

" The determination of function(s) is a requisite for all Value studies". "All cost is for function".

Thus after the steps in the Information Phase have been completed, the next task is to investigate the project thoroughly using function analysis. Function analysis is concerned with locating unnecessary costs and specific requirements and determining the value of the project selected for study.

A function is that which makes an item or service work or sell - in other words; an item's function is why the customer buys the product or service. An item, including structures and services, is a means to the end of providing a function, not the end itself.

Function Definition

Preliminary attempts to define the functions of an item or process often involve several concepts that seem to need extensive description. Although this could conceivably describe the functions satisfactorily, it is neither concise nor workable enough for successful analysis. The longer the description the more confusing it becomes.

A function is always expressed by a verb and noun. This two-word description has several advantages.

(i) The description pinpoints the functions and is not cluttered with superfluous information, thereby forcing the planner to decide what data is fundamental and should be retained and what is unimportant and should be rejected.

(ii) Possible alternative solutions for providing the functions are not restricted.

(iii) Functions that repeat in the design can easily be identified and often combined or even eliminated.

(iv) And very important, the definitions promote full understanding by all team members regardless of their knowledge, educational and technical backgrounds.

A function must be expressed in a measurable parameter in order to obtain a value for it later in the analysis.

Nouns can be either measurable or nonmeasurable. Nonmeasurable nouns must be explained so that they can be translated into a measurable element and later evaluated.

II. Classifying Functions

In value studies functions exist in two categories - basic and secondary.

1. Basic function is the primary purpose(s) for which the item or service was designed when it is operating in its normally prescribed manner. This function must be accomplished to meet the purpose of the product, structure, or service. A product or service may have more than one basic function.
2. Secondary functions are ones that support the basic function (and hence are sometimes referred to as "support functions"). They result from a specific design approach to achieve the basic function. If the design changes, the need for existing secondary functions may be modified or even eliminated. To enhance the analytical an evaluation process some practitioners break secondary functions into a sub-classification of "required" (by the current design, “aesthetic" and “unwanted" such as the “emits heat “function of an overhead projector.

III. Developing Function Relationships

As Value studies became larger and more complicated, it was readily apparent that the Random Function Analysis technique was not adequate. The development of function models depicting relationships of functions within the project became essential and evolved into two major types - Hierarchy and Function Analysis System Technique (FAST) models.

IV. Assigning Cost and/or Other Measurement Criteria to Functions

Another key step in Function Analysis is to relate cost to functions. It is useful to use a Function - Cost Worksheet to assist in the application of the function/cost process. Figure 4 illustrates the allocation of costs to functions for the guiderail assembly. It is the cost function relationship that often vividly illustrates where unnecessary cost exists within the study project.

The procedure is:

1. List the functions within the scope of the project across the top of the form.
2. List parts, major subassemblies/sub-systems steps of a procedure etc. vertically on the left side of the form with their associated costs determined from the Information Phase.
3. Check off which functions are impacted by each item/step.
4. Determine how much cost of each item belongs to each function
5. Add all columns vertically to determine how much cost is allocated to each function.

Function-Cost relationships provide direction for the study team as to opportunities for greatest value improvement on a cost basis. There of course may be other key criteria such as quality, reliability, or producibility. Similar matrices can be developed for those and / or other key management concerns. Figure 5 illustrates a Function-Time matrix for a factor, rehabilitation project.

V. Establishing Function Worth

In the value methodology, worth is defined as the lowest overall cost to perform a function without regard to criteria or codes'. Comparing function cost to function worth is the primary technique to help study teams identify areas of the greatest potential value improvement. Dimensioning the function models or random function worksheets with cost and /or other key performance parameters often in itself highlights obvious functions needing improvement. Typical observations are, “that function costs too much” “all that time for that function?", or “there’s our quality problem “.

VI. Selecting Functions for Study

As discussed above, the very act of establishing the worth of a function will often create obvious choices for improvement. Another step is to create the Value Index. This index reflects the basic value theory that value is the relationship between cost and worth. The formula is:

Value = Worth /Cost

The goal would be to achieve a ratio of 1.0.

Caution is made that the choice of areas to focus on must be made in consonance with the project objectives and goals. It is important to recognize the emphasis may not be on cost but rather other performance factors such as time or quality.

TYPICAL VERBS AND NOUNS FOR DEFINING FUNCTIONS

The following is a partial list of verbs and nouns concerning either "work" or sell" functions.

HARDWARE/STRUCTURE STUDIES:

Work Functions

Verbs			Nouns		
Actuate	Fasten	Prevent	Area	Friction	Repair
Amplify	Filter	Protect	Corrosion	Heat	Rust
Attract	Hold	Rectify	Current	Insulation	Stability
Change	Impede	Remove	Damage	Light	Surface
Collect	Increase	Reduce	Density	Noise	Torque
Conduct	Induce	Repel	Energy	Oxidation	Vibratio
Contain	Insulate	Rotate	Flow	Power	Voltage
Control	Interrupt	Secure	Fluid	Protection	Volume
Direct	Limit	Shield	Force	Radiation	Weight
Distribute	Locate	Shorten			
Emit	Modulate	Support	Undesirable Nouns		
Enclose	Mount	Test	Article	Component	Item
Establish	Move	Transmit	Assembly	Device	Part

Sell Functions

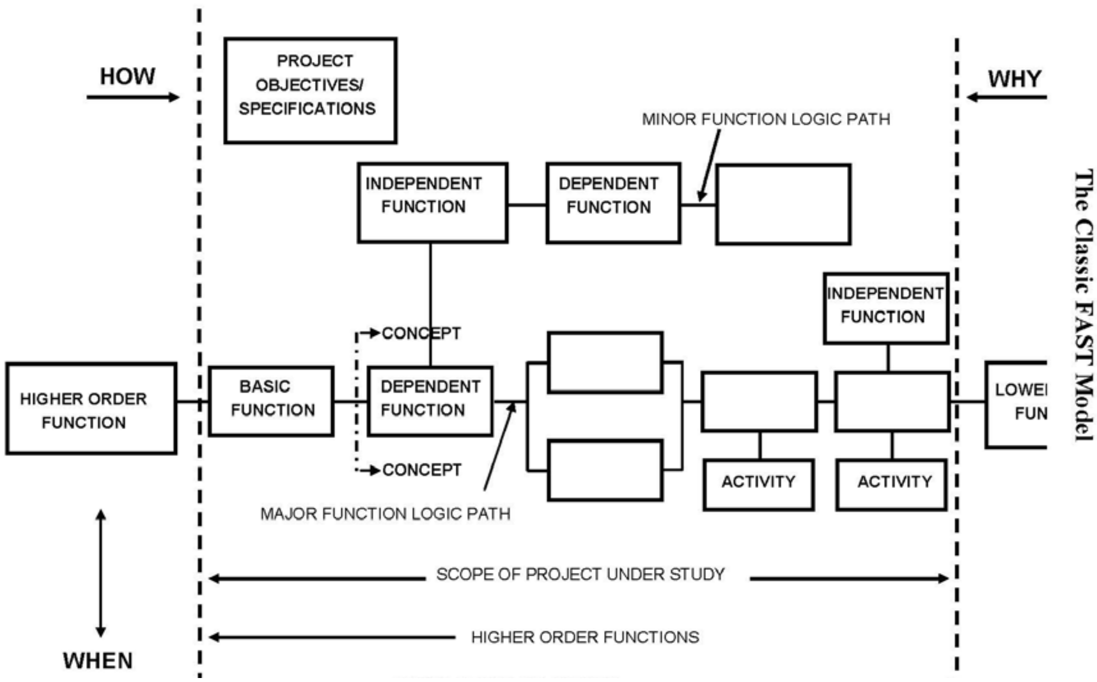
Verbs			Nouns		
Attract	Enhance	Increase	Appearance	Effect	Form
Create	Illustrate	Maintain	Beauty	Exchange	Prestige
Decrease	Improve	Satisfy	Convenience	Features	Style

MANUFACTURING/PROCESS STUDIES

Verbs			Nouns		
Allow	Form	Remove	Corrosion	Equipment	Shape
Apply	Generate	Resist	Current	Fixtures	Supplies
Bake	Improve	Restrict	Decor	Flow	Tools
Band	Increase	Shape	Effort	Force	Torque
Compress	Inspect	Shrink	Electricity	Light	Voltage
Decrease	Lift	Sort	Energy	Material	Waste
Discard	Load	Store	Environment	Motion	Weight
Drive	Minimize	Support			
Dry	Modify	Transmit			
Eliminate	Move	Transport			
Finish	Produce	Verify			
Fire	Receive	Weigh			

THE MECHANICS OF *THE* PROCESS

To begin the process, a basic model is offered. The following figure is showing the FAST components and describing their parts.



A. Scope Of the problem under study

Depicted as two vertical dotted lines-, the scope lines bound the problem under study, or that aspect of the problem with which the study team is involved.

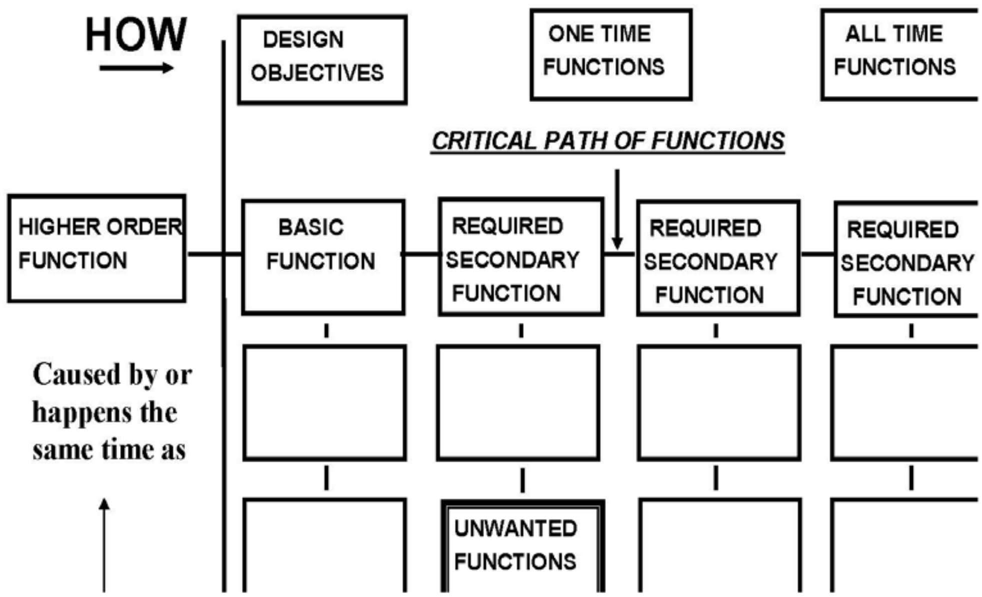
B. Highest order function(s)

The objective or output of the basic function(s) and subject under study, is referred to as the highest order functions, and appears outside the left scope line, and to the left of the basic functions.

Note: Any function to the left of another on the critical path is a "higher" order function

C. Lowest Order Function

These functions to the right and outside of the right scope line represent the input side that "turn on" or initiates the subject tinder study and are known as lowest order functions. Any function to the right of another function or the critical path is a "lower" order function.



The Technical FAST Model

D. Basic Function(s)

Those function(s) to the immediate right of the left scope line representing the purpose or mission of the subject under study.

E. Concept

All functions to the right of the basic function(s) describe the approach elected to achieve the basic function(s). The "concept" represents either existing conditions or proposed approach, which approach to use (current or proposed) is determined by the task team and the nature of the problem under study.

F. Objective or Specifications

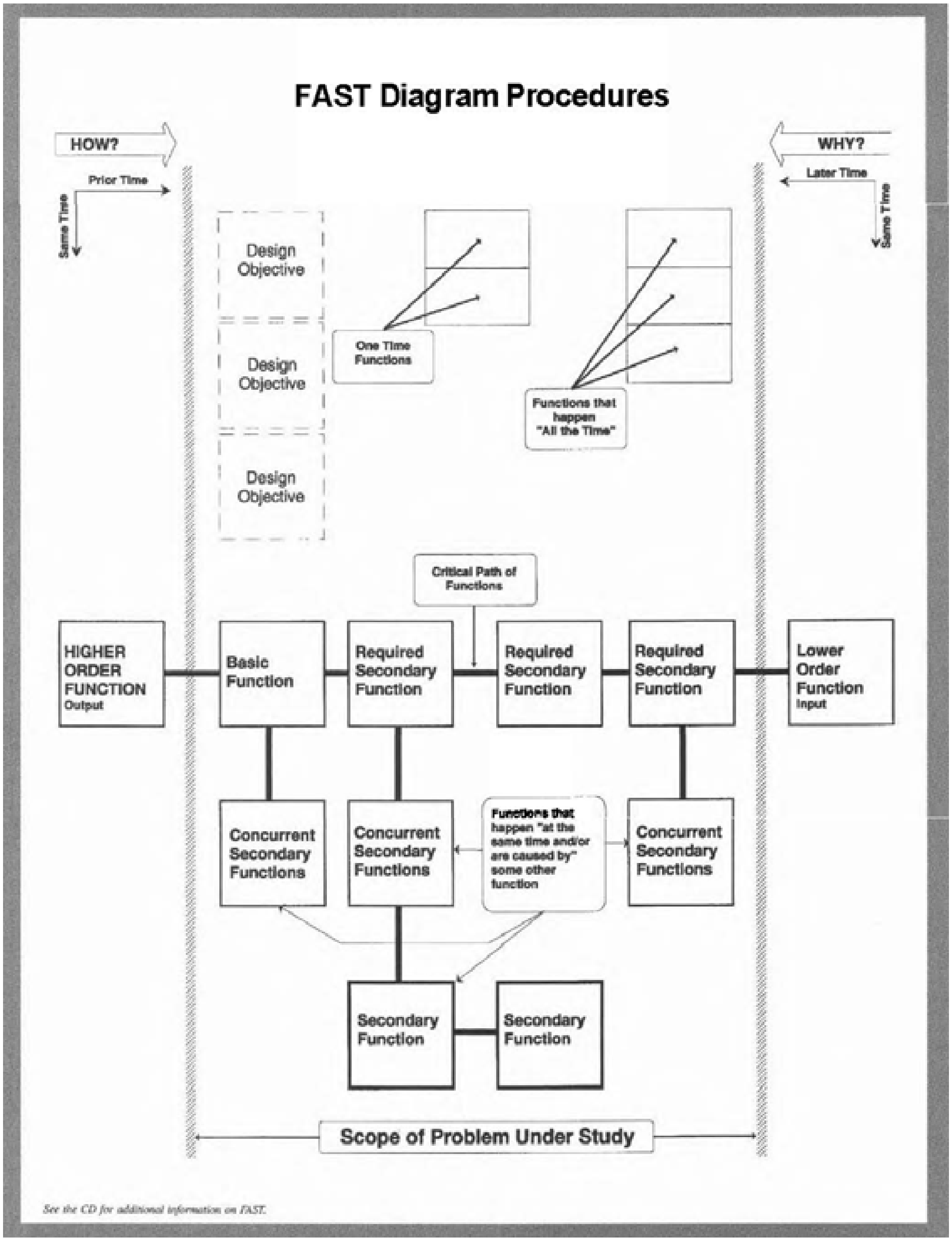
Objective or specifications are particular parameters or restrictions which must be achieved to satisfy the highest order function in its operating environment. Although they are not themselves functions, they may influence the concept selected to best achieve the basic function(s) and satisfy the users requirements.

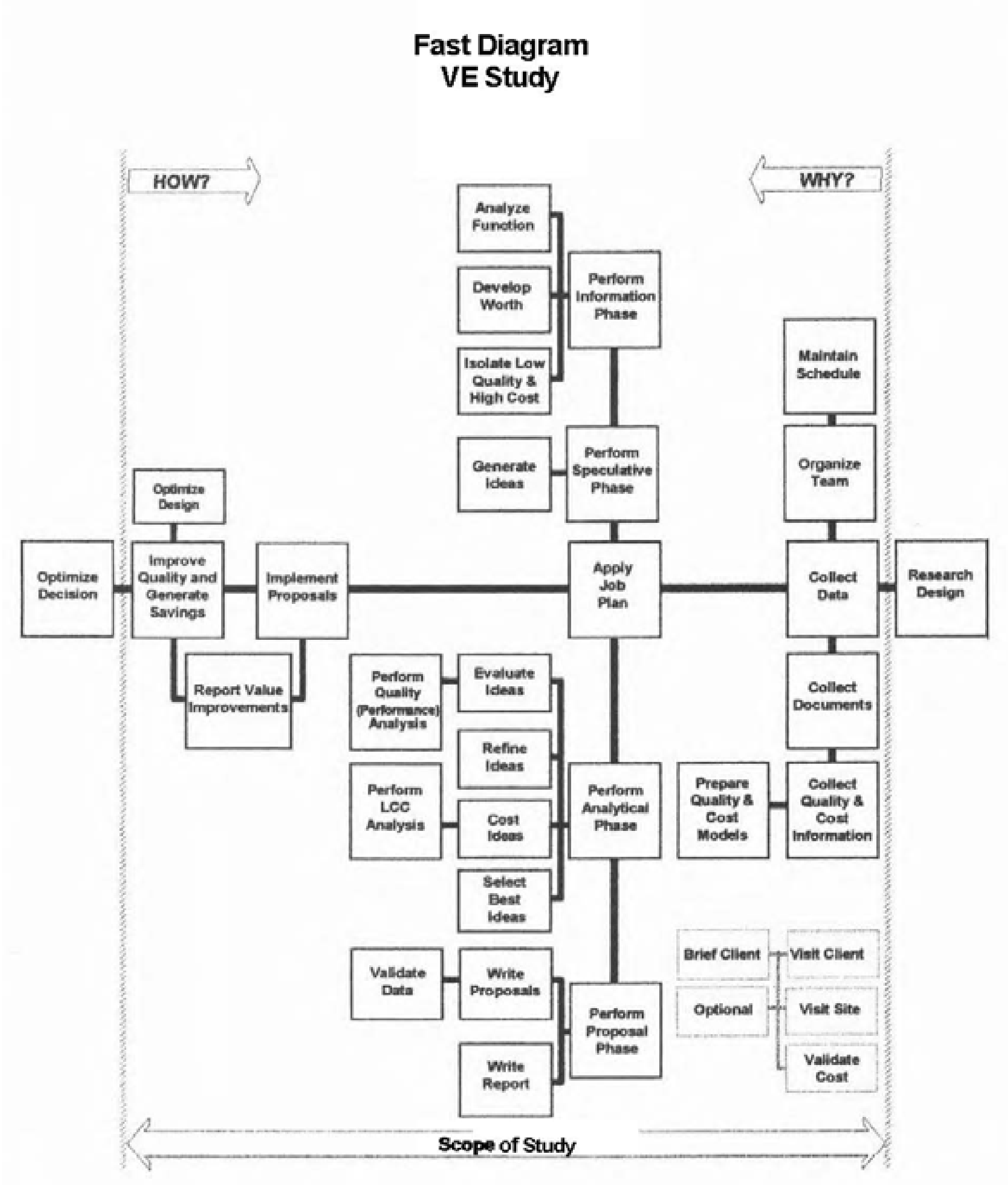
G. Critical Path Function(s)

Any function on the How or why logic is a critical path function If a function along the why direction enters the basic function(s) it is a major critical path, otherwise it will conclude in an independent (supporting) function and be a minor critical path.

H. Dependent Functions

Starting with the first function to the right of the basic function, each successive function is "dependent" on the one to its immediate left or higher order function, for its existence. That dependency becomes more evident when the *How* question and direction is followed.



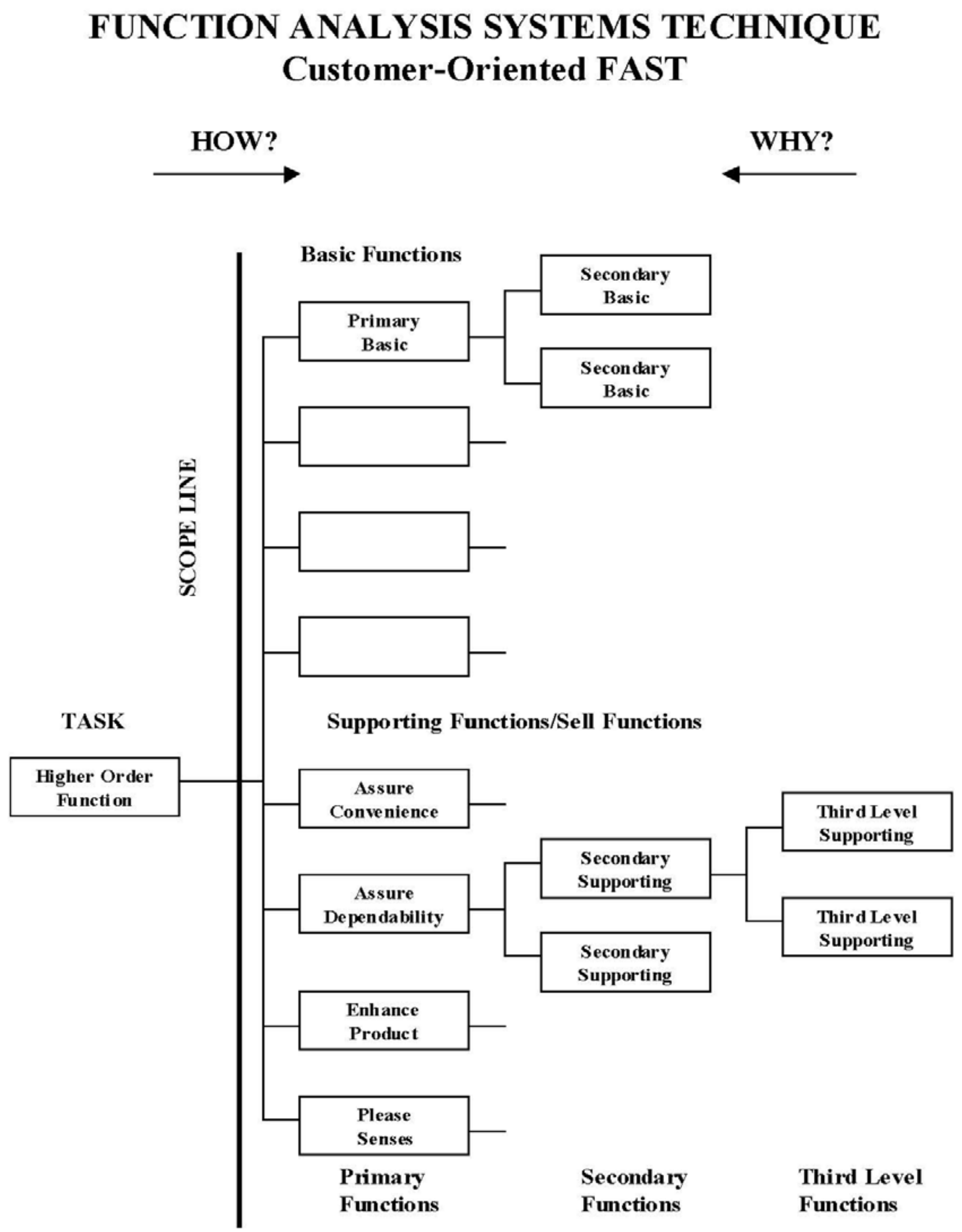

Fast Diagram
VE Study
HOW?
WHY?
Analyze Function
Develop Worth
Isolate Low Quality & High Cost
Perform Information Phase
Maintain Schedule
Generate Ideas
Perform Speculative Phase
Organize Team
Optimize Design
Optimize Decision
Improve Quality and Generate Savings
Implement Proposals
Apply Job Plan
Collect Data
Research Design
Report Value Improvements
Perform Quality (Performance) Analysis
Evaluate Ideas
Collect Documents
Refine Ideas
Perform LCC Analysis
Cost Ideas
Perform Analytical Phase
Prepare Quality & Cost Models
Collect Quality & Cost Information
Select Best Ideas
Brief Client
Visit Client
Validate Data
Write Proposals
Optional
Visit Site
Perform Proposal Phase
Validate Cost
Write Report
Scope of Study

I. Independent (or Supporting) Function (s)

Functions that do not depend on another function, or method selected to perform that function. Independent functions are located above the critical path function(s), and are considered secondary, with respect to the scope, nature, and level of the problem, and its critical path.

J. Function

An end or purpose that a “ thing" or activity is intended to perform, expressed in a verb-noun form.



K. Activity

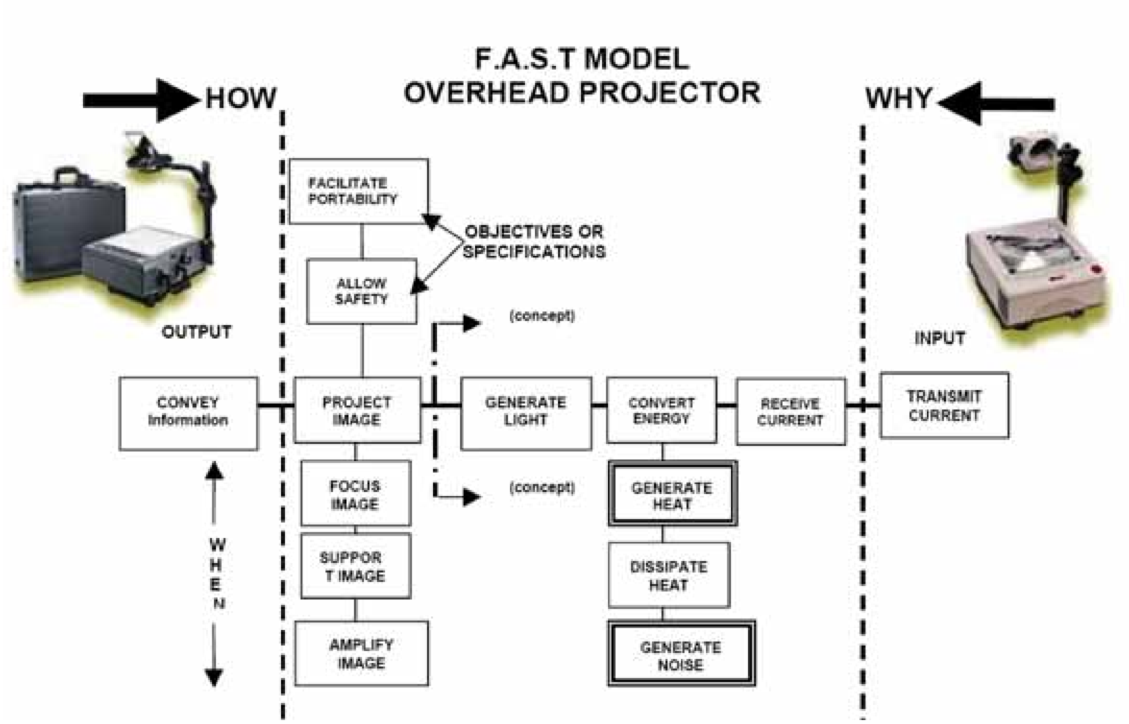
The method selected to perform a function (or group of functions).

To those who are system oriented, it would appear that the FAST diagram is constructed backwards, because in systems terms (or the why direction) the "input" is normally to the left side, and the "output" to the right. However, note that when a method to perform a function on the critical path is changed, it affects all functions to the right of the changed function, or stating it in function analysis terms, changing a function will alter the functions dependent upon it. Therefore, the How (reading left to right) and why (reading right to left) directions are properly oriented in FAST logic.

FAST MODEL EXAMPLE

Now that you have an idea of the FAST concept, let's try an example. Remember the overhead projector mentioned earlier? We have already identified several functions. The objective, or higher order function is "convey information."

The basic function, since we have chosen the overhead projector as the method that is going to be used to "convey information" is "project image. " Next we ask, "How do you 'project image'?" A logical answer to that question is by "generate light." These functions are place on the FAST model from left to right.



Next the functions are tested in the "Why" direction. This will identify any missing functions because it won't sound right if there is one missing. Therefore, why do you "generate light?" Answer: To "project image." And, why do you "project image?' To "convey information." This process is continued until all the functions identified function brainstorming exercise are exhausted.

The idea is to complete the critical path first. Once the critical path has been extended to the point it is out of the scope of the system, the remaining functions are positioned in the when direction to describe the supporting functions, independent functions, specifications and activities that fully describe the system.

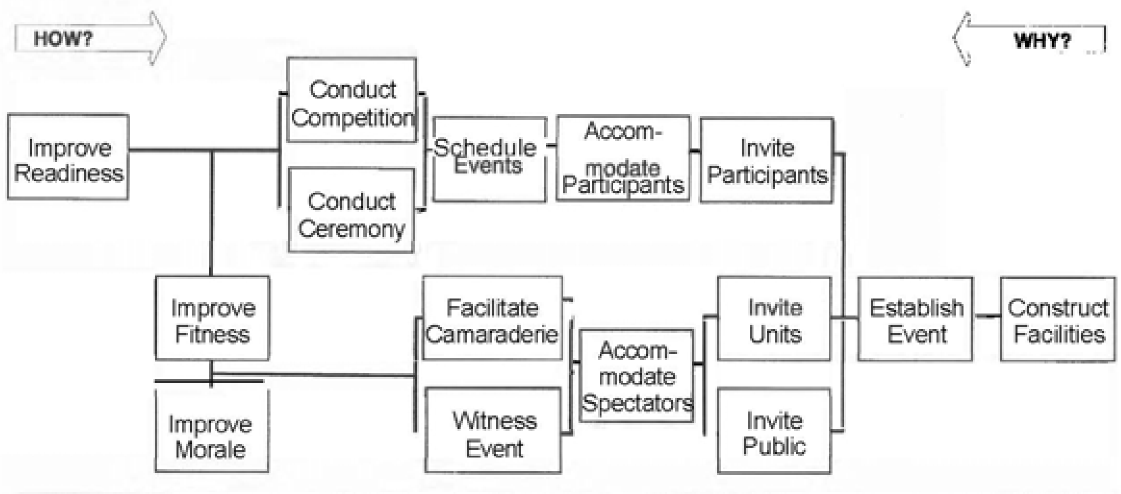
Now, note the supporting functions under "convert energy." The functions with the double lines around them, "generate heat" and "generate noise," are "unwanted", or "undesirable" functions. In the case of the overhead projector, the "generate heat" function is caused by the light bulb used to "convert energy" in order to "generate light." Excessive heat buildup significantly reduces the life of the light bulb.

Therefore, the "dissipate heat" function has been added to resolve this problem. In doing so, however, it has caused another unwanted function, "generate noise."

Next, the objectives, or specifications can be added to the diagram. Note the "facilitate portability" and "allow safety" specification functions positioned over the basic function "project image." These are specified by the customer, regulations, or other sources. This is one way of depicting these functions, or, other methods simply position them in the upper right corner of the diagram. These are also called "all the time" functions.

Once the whole system has been described using the FAST model, opportunities can be identified for improvement in the system if this is a re-engineering project. Alternatively, if it is a product development effort, opportunities can be seen to avoid problems, improve the original design, and reduce cost. In the Value Engineering methodology, cost would be allocated to the functions in order to identify the high cost functions.

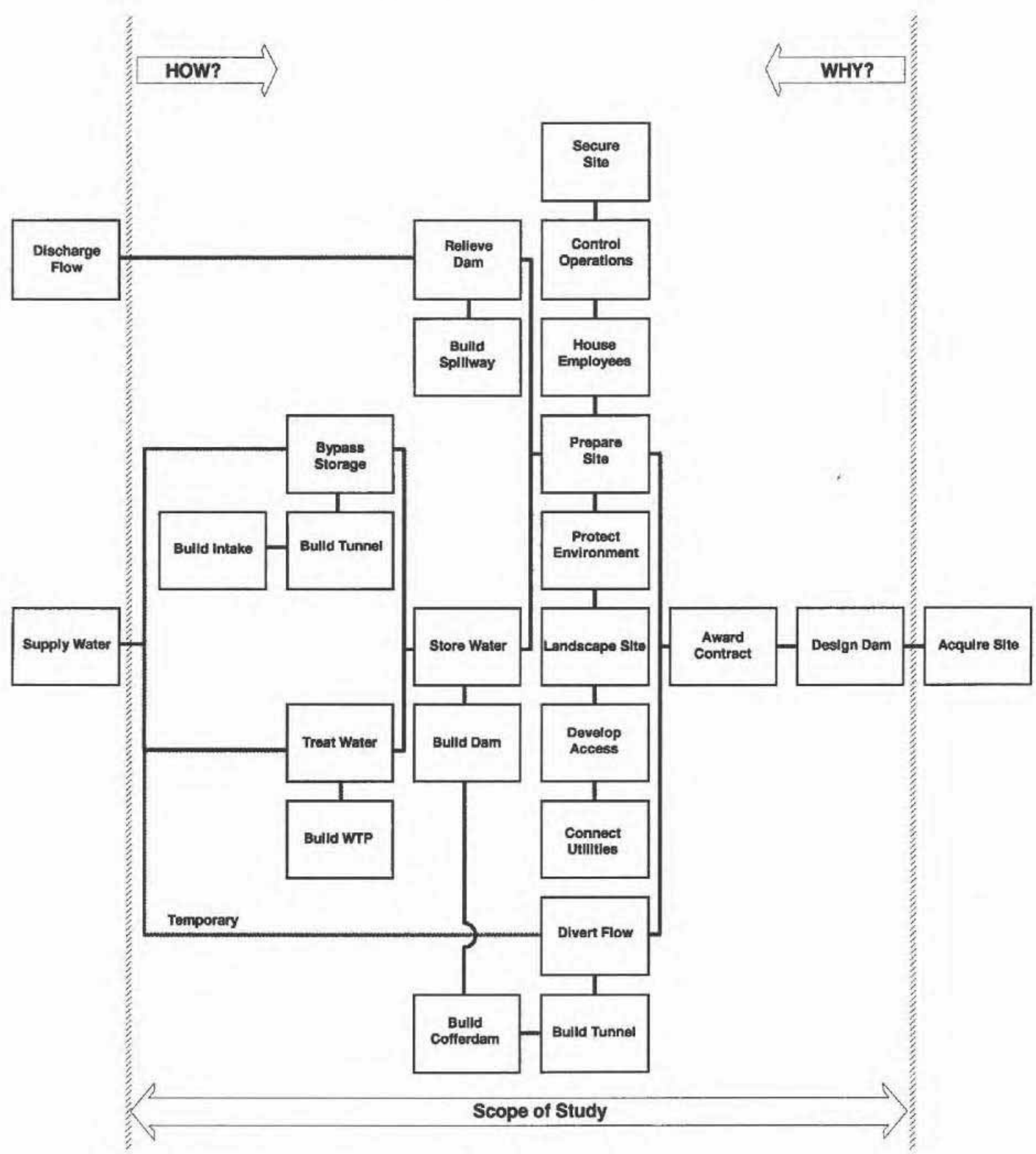
FAST Diagram - Stadium



- **Accommodate Participants**
- **Construct:**
  - Field/Track
  - Locker/Toilets
  - Referee Space
  - First Aid
  - Equipment Storage

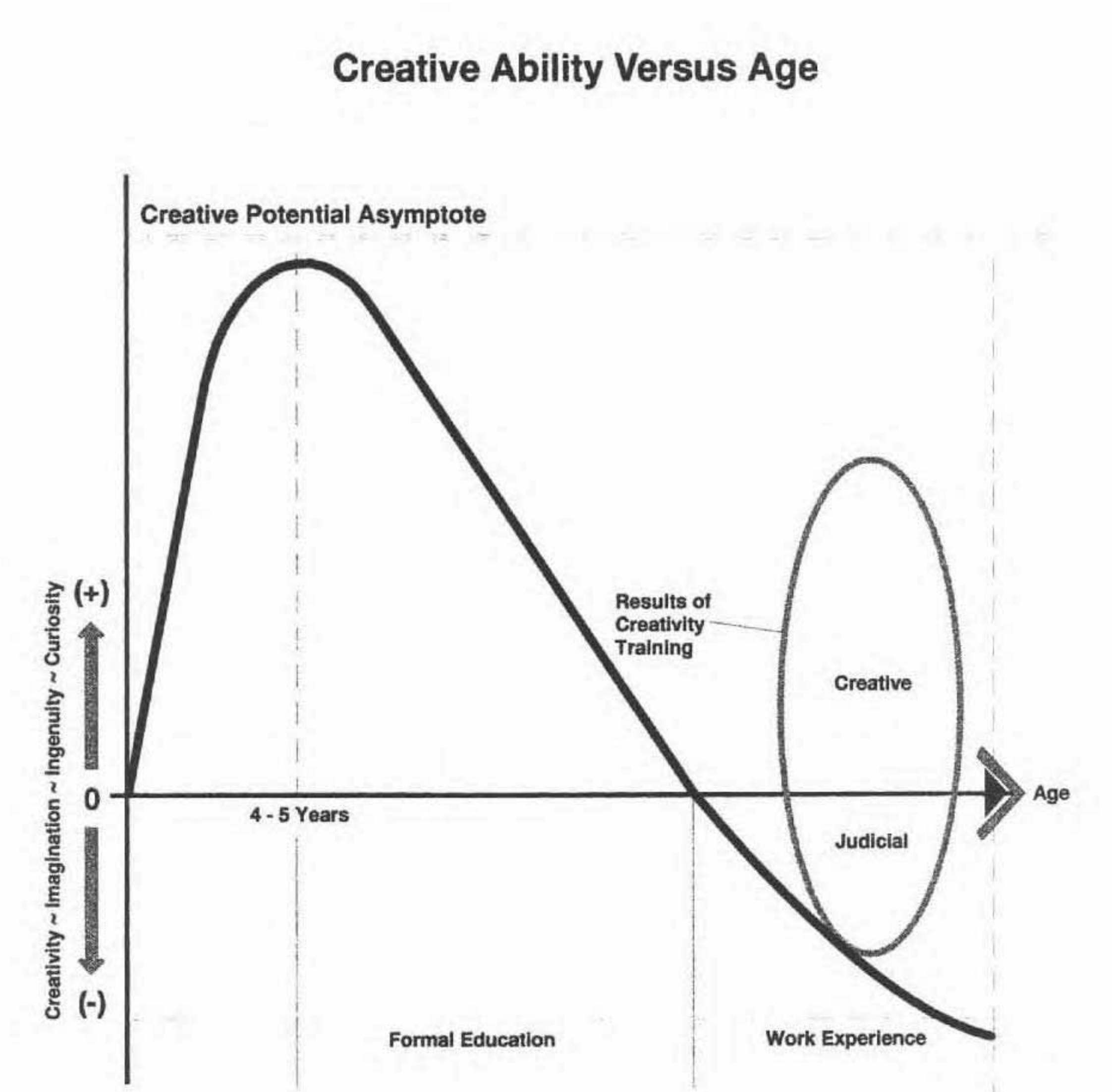
- **Accommodate Spectators**
- **Construct:**
  - Bleachers
  - Concessions
  - Toilets
  - *Support Space

FAST Diagram
Dam for Large Water Reservoir



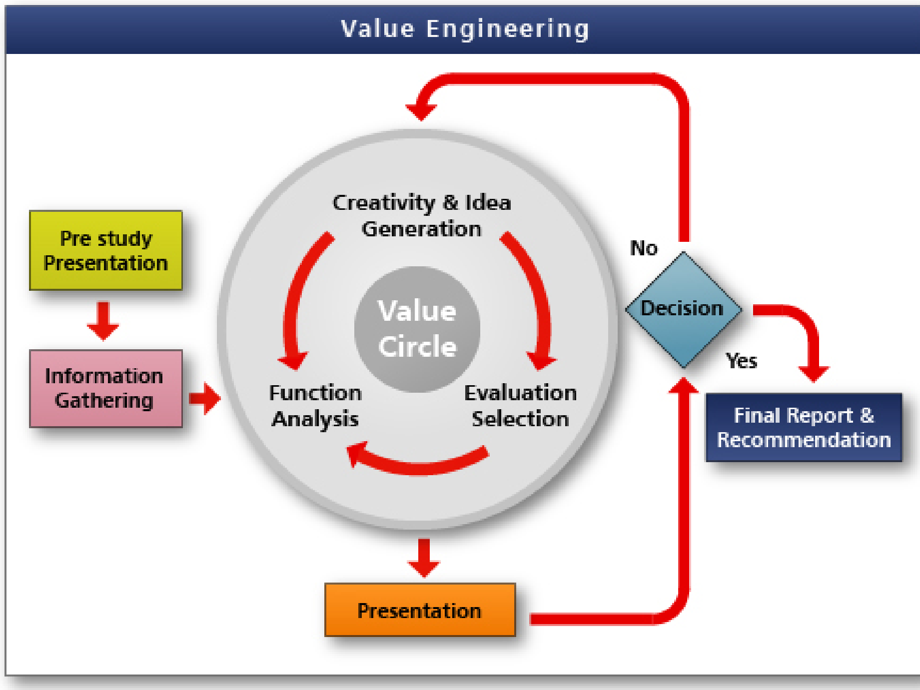
C. Creative Phase

The objective of the Creative Phase (sometimes referred to as Speculation Phase) is to develop a large quantity of ideas for performing each function selected for study. This is a Creative type of effort, totally unconstrained by habit, tradition, negative attitudes, assumed restrictions, and specific criteria. No judgment or discussion occurs during this activity. The quality of each idea will be developed in the next phase, from the quantity generated in this phase.



There are to keys to successful speculation: first, the purpose of this phase is not to Conceive of ways to design a product or service, but to develop ways to perform the functions selected for study. Secondly, creativity is a mental process in which past experience is a combined and recombined to form new combination. The purpose is to create new combinations which will perform the desired function at less total cost and improved performance than was previously attainable.

There are numerous well-accepted idea generation techniques. The guiding principle in all of them is that judgment / evaluation is suspended. Free flow of thoughts and ideas - without criticism - is required.



D. Evaluation Phase

The objectives of the Evaluation Phase are to synthesize ideas and concepts generated in the Creative Phase and to select feasible ideas for development into specific value improvement.

Using the evaluation criteria established during the Pre-Study effort, ideas are sorted and rated as to how well they meet those criteria. The process typically involves several steps:

1. Eliminate nonsense or "thought- provoker" ideas.
2. Group similar ideas by category within long term and short term implications. Examples of groupings are electrical, mechanical, structural, materials, special processes, etc.
3. Have one team member agree to "champion" each idea during further discussions and evaluations. If no team member so volunteers, the idea, or concept is dropped.

4. List the advantages and disadvantages of each idea.
5. Rank the ideas within each category' according to the prioritized evaluation criteria using such techniques as indexing, numerical evaluation, and team consensus.
6. If competing combinations still exist, use matrix analysis to rank mutually exclusive ideas satisfying the same function.
7. Select ideas for development of value improvement.

If none of the final combinations appear to satisfactorily meet the criteria, the value study team returns to the Creative Phase

E. Development Phase

The objective of the Development Phase is to select and prepare the "best" alternative(s) for improving value. The data package prepared by the champion of each of the alternatives should provide as much technical, cost, and schedule information as practical so the designer and project sponsor(s) may make an initial assessment concerning their feasibility for implementation. The following steps are included:

1. Beginning with the highest ranked value alternatives, develop a benefit analysis and implementation requirements, including estimated initial costs, life cycle costs, and implementation costs taking into account risk and uncertainty.
2. Conduct performance benefit analysis.
3. Compile technical data package for each proposed alternative.
   a. written descriptions of original design and proposed alternative(s).
   b. sketches of original design and proposed alternative (s)
   c. cost and performance data, clearly showing the differences between the original design and proposed alternative (s).
   d. any technical back-up data such as information sources, calculations, and literature
   e. schedule impact
4. Prepare an implementation Plan, including proposed schedule of all implementation activities, team assignments and management requirementsز
5. Complete recommendations including any unique conditions to the project under study such as emerging technology. political concerns, impact on other ongoing projects, marketing plans, etc.

F. Presentation Phase

The objective of the Presentation Phase is to obtain concurrence and a commitment from the designer, project sponsor, and other management to proceed with implementation of the recommendations. This involves an initial oral presentation followed by a complete written report.

As the last task within a value study, the VM study team presents its recommendations to the decision making body. Through the presentation and its interactive discussions, the team obtains either approval to proceed *with* implementation, or direction for additional information needed.

The written report documents the alternatives proposed with supporting data and confirms the implementation plan accepted by management. Specific organization of the report is unique to each study and organization requirements.

3. POST STUDY

The objective during Post-Study activities is to assure the implementation of the approved value study change recommendations. Assignments are made either to individuals within the VM study team, or by management to other individuals, to complete the tasks associated with the approved implementation plan.

While the VM Team Leader may track the progress of implementation, in all cases the design professional is responsible for the implementation. Each alternative must be independently designed and confirmed, including contractual changes if required, before its implementation into the product, project, process, or procedure. Further, it is recommended that appropriate financial departments (accounting, auditing, etc.) conduct a post audit to verify to management the full benefits resulting from the value methodology study.

QUALITY FUNCTION DEPLOYMENT

Introduction

Quality function deployment enables the design phase to concentrate on the customer requirements, thereby spending less time on redesign and modifications. The saved time has been estimated at one-third to one-half of the time taken for redesign and modification using traditional means. This saving means reduced development cost and also additional income because the product enters the market sooner.

The QFD Team

When an organization decides to implement QFD, the project manager and team members need to be able to commit a significant amount of time to it, especially in the early stages. The priorities of the projects need to be defined and told to all departments within the organization so team members can budget their time accordingly. Also, the scope of the project must be clearly defined so questions about why the team was formed do not arise. One of the most important tools in the QFD process is communication.

Benefits of QFD

Quality function deployment was originally implemented to reduce start-up costs. Organizations using QFD have reported a reduced product development time. For example, U.S. car manufacturers of the late 1980s and early 1990s needed an average of five years to put a product on the market, from drawing board to showroom, whereas Honda put a new product on the market in two and a half years and Toyota did it in three years. Both organizations credit this reduced time to the use of QFD. Product quality and, consequently, customer satisfaction improve with QFD due to numerous factors depicted in Figure 1.

Customer Driven

Quality function deployment looks past the usual customer response and attempts to define the requirements in a set of basic needs, which are compared to all competitive information. All competitors are evaluated equally from customer and technical perspectives. This information can then be prioritized using a Pareto diagram. Management can then place resources where they will be the most beneficial in improving quality. Also, QFD takes the experience and information that are available within an organization and puts them together as a structured format that is easy to assimilate.

Reduces Implementation Time

Fewer engineering changes are needed when using QFD, and, when used properly, all conflicting design requirements can be identified and addressed prior to production.

This results in a reduction in retooling, operator training, and changes in traditional quality control measures. By using QFD, critical items are identified and can be monitored from product inception to production. Toyota reports that the quality of their product has improved by one-third since the implementation of QFD.

Promotes Teamwork

Quality function deployment forces a horizontal deployment of communication channels. Inputs are required from all facets of an organization, from marketing to production to sales, thus ensuring that the voice of the customer is being heard and that each department knows what the other is doing. This activity avoids misinterpretation, opinions, and miscues. In other words, the left hand always knows what the right hand is doing. Efficiency and productivity always increase with enhanced teamwork.

Provides Documentation

A database for future design or process improvements is created. Data that are historically scattered within operations, frequently lost and often referenced out of context, are now saved in an orderly manner to serve future needs. This database also serves as a training tool for new engineers. Quality function deployment is also very flexible when new information is introduced or things have to be changed on the QFD matrix.

The Voice of the Customer

Because QFD concentrates on customer expectations and needs, a considerable amount of effort is put into research to determine customer expectations. This process increases the initial planning stage of the project definition phase in the development cycle. But the result is a total reduction of the overall cycle time in bringing to the market a product that satisfies the customer.

Quality function deployment begins with marketing to determine what exactly the customer desires from a product. During the collection of information, the QFD team must continually ask and answer numerous questions, such as:

- What does the customer really want?
- What are the customer's expectations?
- Are the customer's expectations used to drive the design process?
- What can the design team do to achieve customer satisfaction?

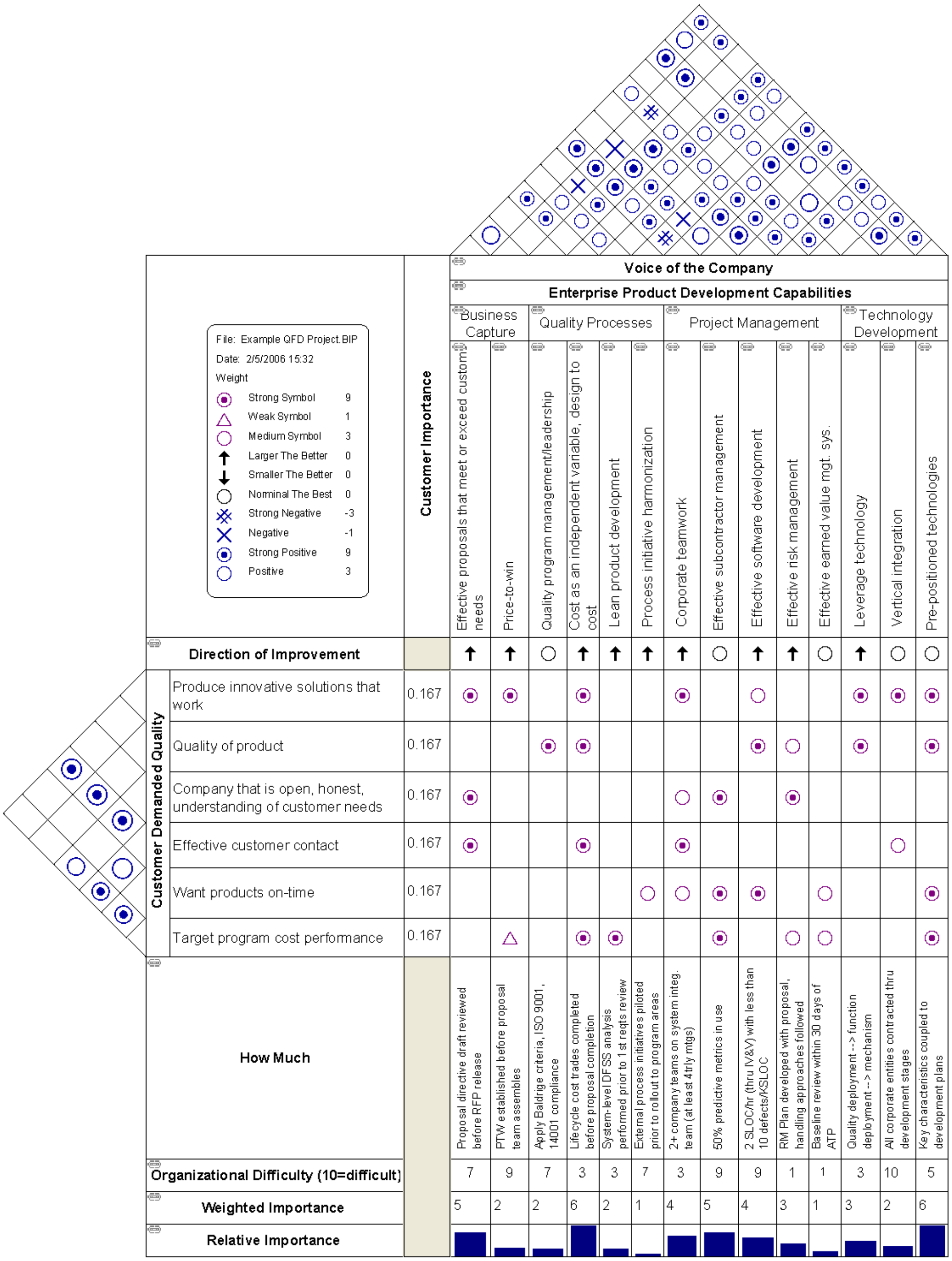
The goal of QFD is not only to meet as many customer expectations and needs as possible, but also to exceed customer expectations. Each QFD team must make its product either more appealing than the existing product or more appealing than the product of a competitor. This situation implies that the team has to introduce an expectation or need in its product that the customer is not expecting but would appreciate. For example, cup holders were put into automobiles as an extra bonus, but customers liked them so well that they are now expected in all new automobiles.

House of Quality

The primary planning tool used in QFD is the house of quality. The house of quality translates the voice of the customer into design requirements that meet specific target values and matches those against how an organization will meet those requirements. Many managers and engineers consider the house of quality to be the primary chart in quality planning.

The parts of the house of quality are described as follows:

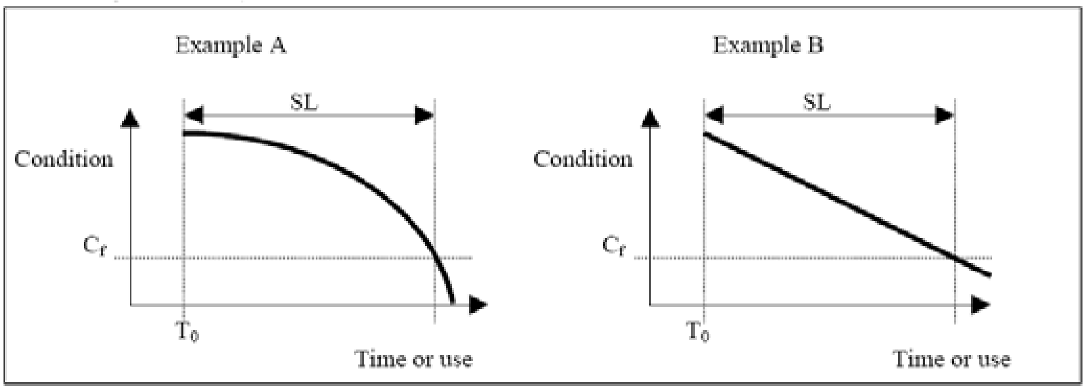
The exterior walls of the house are the customer requirements. On the left side is a listing of the voice of the customer, or what the customer expects in the product. On the right side are the prioritized customer requirements, or planning matrix.


File: Example QFD Project.BIP
Date: 2/5/2006 15:32
Weight
Strong Symbol 9
Weak Symbol 1
Medium Symbol 3
Larger The Better 0
Smaller The Better 0
Nominal The Best 0
Strong Negative -3
Negative -1
Strong Positive 9
Positive 3
Customer Importance
Voice of the Company
Enterprise Product Development Capabilities
Business Capture
Quality Processes
Project Management
Technology Development
Effective proposals that meet or exceed customer needs
Price-to-win
Quality program management/leadership
Cost as an independent variable, design to cost
Lean product development
Process initiative harmonization
Corporate teamwork
Effective subcontractor management
Effective software development
Effective risk management
Effective earned value mgt. sys.
Leverage technology
Vertical integration
Pre-positioned technologies
Direction of Improvement
Customer Demanded Quality
Produce innovative solutions that work 0.167
Quality of product 0.167
Company that is open, honest, understanding of customer needs 0.167
Effective customer contact 0.167
Want products on-time 0.167
Target program cost performance 0.167
How Much
Proposal directive draft reviewed before RFP release
PTW established before proposal team assembles
Apply Baldrige criteria, ISO 9001, 14001 compliance
Lifecycle cost trades completed before proposal completion
System-level DFSS analysis performed prior to 1st reqts review
External process initiatives piloted prior to rollout to program areas
2+ company teams on system integ. team (at least 4trly mtgs)
50% predictive metrics in use
2 SLOC/hr (thru IV&V) with less than 10 defects/KSLOC
RM Plan developed with proposal, handling approaches followed
Baseline review within 30 days of ATP
Quality deployment --> function deployment --> mechanism
All corporate entities contracted thru development stages
Key characteristics coupled to development plans
Organizational Difficulty (10=difficult) 7 9 7 3 3 7 3 9 9 1 1 3 10 5
Weighted Importance 5 2 2 6 2 1 4 5 4 3 1 3 2 6
Relative Importance

QFD Process

The QFD matrix (house of quality) is the basis for all future matrices needed for the QFD method. Although each house of quality chart now contains a large amount of information, it is still necessary to refine the technical descriptors further until an actionable level of detail is achieved. Often, more than one matrix will be needed, depending on the complexity of the project. The process is accomplished by creating a new chart in which the HOWs (technical descriptors) of the previous chart become the WHATs (customer requirements) of the new chart. This process continues until each objective is refined to an actionable level. The HOW MUCH (prioritized technical descriptors) values are usually carried along to the next chart to facilitate communication. This action ensures that the target values are not lost during the QFD process. If the target values are changed, then the product is not meeting the customer requirements and not listening to the voice of the customer, which defeats the purpose of QFD.

As a long-term, multi-year investment, a bridge is the product of decisions made and actions taken during its planning, design, construction, use and maintenance over the course of many years. Possibly the most basic issue in BLCCA is the determination of how long a bridge's service life is likely to be. In practice, the end of a bridge's useful life often comes decades or even centuries after its initial construction.

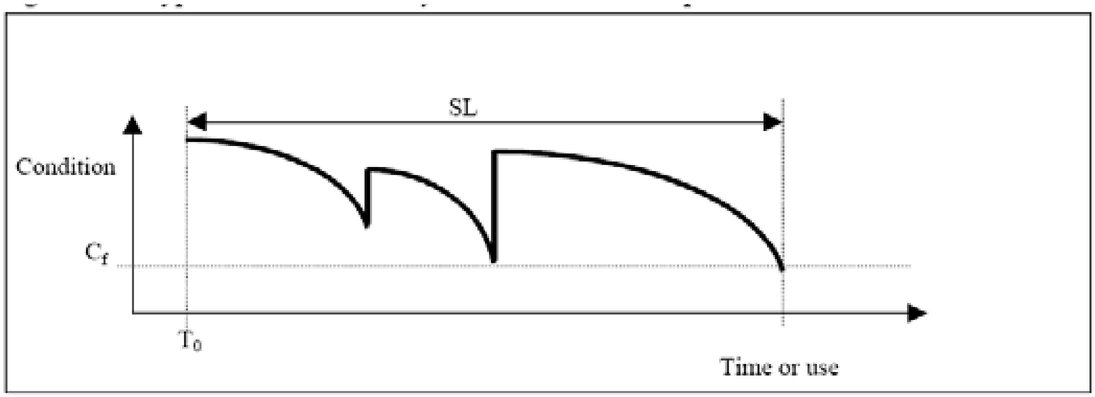


Models of bridge deterioration

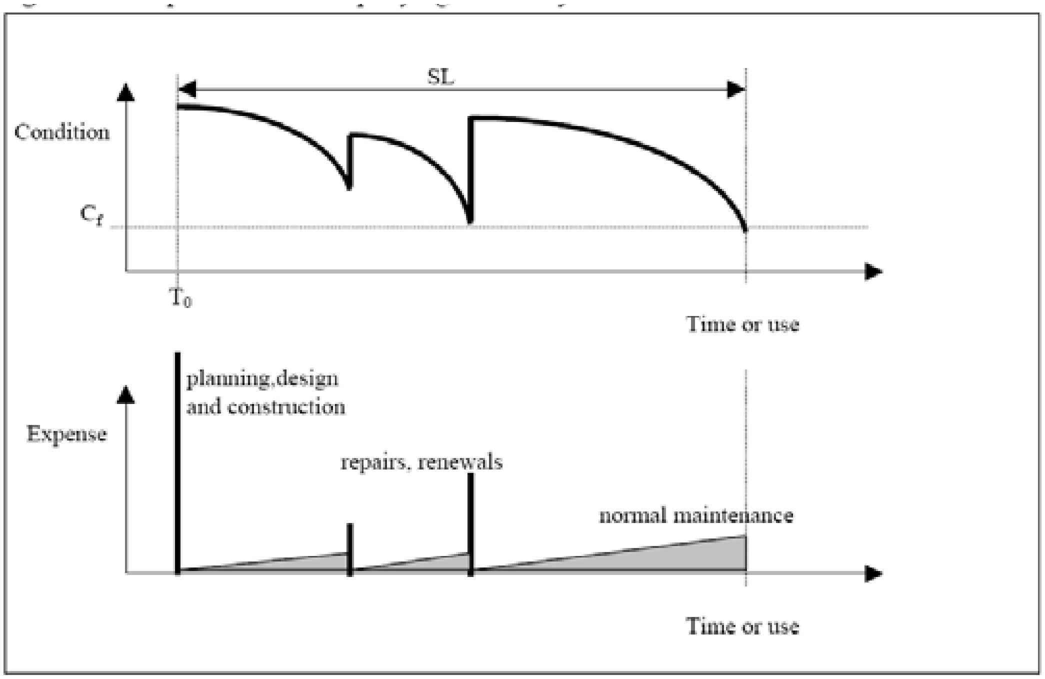
Figure 2.1 illustrates typical representations of a how the condition of a bridge or its elements deteriorate and define the service life, in the absence of any particular action to make repairs or otherwise change conditions. This basic model applies to a bridge as a whole or to any of its *elements*, e.g., deck, substructure, bearings, columns.

If a bridge is placed in service following its construction (at time T_0), the deterioration curve represents the bridge's condition as it declines with wear and aging, from its initially high level to a level considered unacceptable (C_f) . Example A might represent a concrete deck where the damage of gradual cracking accumulates and then begins to accelerate as water and chemicals penetrate more deeply beneath the surface.

Example B might be more representative of a bridge as a whole where the overall condition progresses through a series of defined states. The shape of the deterioration curve, of course, is dependent of the definition of the various condition states. Regardless of the deterioration curve's shape, the service life (SL) represents the length of time until unacceptable conditions prevail.



Typical model of life-cycle condition repairs



Expenditure accompanying the life cycle

In most cases a bridge is not left to follow the basic deterioration path and reach an unacceptable condition without interruption. Instead, the responsible agency will from time to time undertake *repairs*, *rehabilitations*, or *renewals* that return conditions to a higher level and extend the service life.

The sequence of actions and events that determine the bridge-element's condition throughout its life cycle is sometimes referred to as the "life-cycle activity profile." Actions will typically have associated expenditures and these expenditures may be plotted as a function of the time when the expenditures are made.

Time-Value and Equivalence of Economic Resources

The various actions taken during a bridge's life cycle entail use of economic resources. An agency spends money for construction, normal maintenance and repairs. Bridge users sacrifice time and out-of-pocket expenses (e.g., extra fuel) while repairs are being made, for the sake of the improved conditions and extended service life gained thereby. These uses of resources occur at times throughout the service life.

The relationship between the amount of a future expenditure and its equivalent present worth or value is then calculated using the discount rate [*DR*]:

$$PV = FV_N / (1 + DR)^N$$

where:

PV	=	*present value of the expenditure*
FV_N	=	*future value of an expenditure made at time N*
N	=	*# of periods (generally years) between the present and future times*

The discount rate (DR) generally is described as having three components measuring

1. the "real" opportunity cost of capital [cc],
2. the required premium for financial risk associated with investments to be analyzed [f_r], and
3. the anticipated rate of inflation in prices [p_i].

Each component is typically stated as a percentage representing the rate of annual increase (or decrease, in the event of economic deflation), and the "current" discount rate is calculated as

$$DR = [1 + cc][1 + fr][1 + pi] - 1$$

The opportunity-cost of capital is sometimes termed the "real" discount rate. Historical trends suggest that the real time-value of money is typically in the range of 2 to 4 percent per year.

Because the three components of the discount rate are typically small fractions, the second- and third-order terms in the discount-rate equation above are sometimes neglected to yield a frequently used approximation

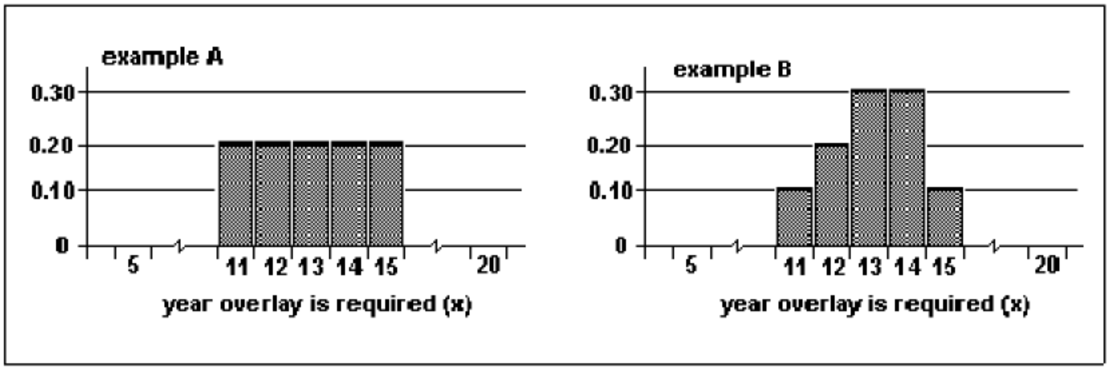
$$DR = cc + fr + pi$$

As long as inflation rates and required risk premiums are low, errors associated with this approximation remain relatively small. The federal-agency discount rate may then be understood to represent a “real” cost of capital of about 4 percent and an anticipated inflation rate of just over 2 percent.

Financial intermediaries such as mortgage lenders may charge 2 to 4 percent over this risk-free level, to cover their costs of doing business and the risks of non-payment and higher-than-expected inflation.

Uncertainty

A simple form of probability distribution will often be used to represent many uncertain parameters in BLCCA, formed from a few specific values assumed to be plausible for the parameter in question.



Examples of discrete probability density distributions

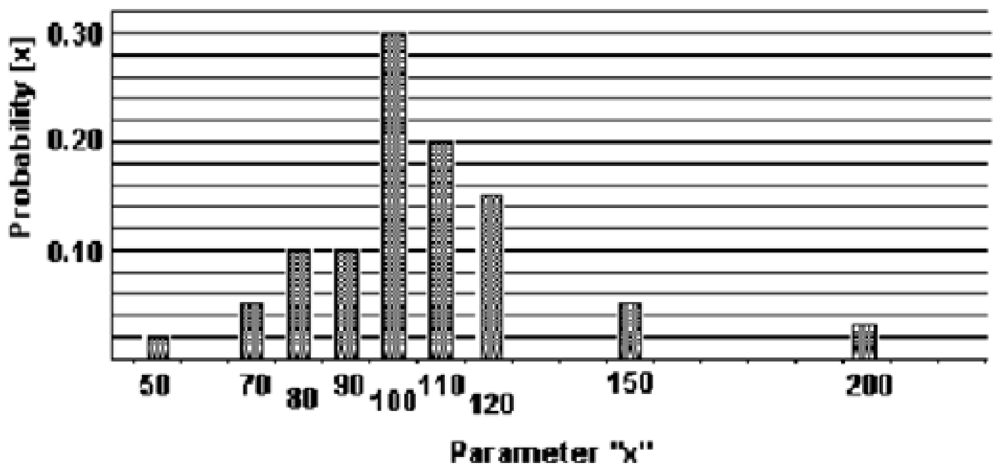
For example, the time required for a bridge-deck's surface condition to deteriorate from its value at the end of construction to a low level that warrants a deck overlay might be estimated as 11 to 15 years (assuming normal maintenance).

If the analyst feels the need for the overlay is equally likely to occur in any one of the five one-year periods of this range (example A), the probability of its occurring in any particular year is 20 percent for years 11 through 15, and 0 otherwise. If he or she has some reason to assume otherwise, greater probability may be assigned to one or another period (e.g., example B), as long as the total probability assignments total to 1.0 or 100 percent.

Example distribution on a "best estimate"

Variation from best estimate value (%)	-50	-30	-20	-10	0	10	20	50	100	Sum
Probability	0.02	0.05	0.10	0.10	0.30	0.20	0.15	0.05	0.03	1.00

Suppose "best estimate" = 100



Probability density distributed on best estimate

BLCCA may often be conducted using a *best estimate* of an uncertain parameter as a basis for estimating (in turn) a probability function for the likely range of that parameter. The analyst bases the initial "best estimate" on limited available data, his or her judgment, or perhaps default values suggested in a guidance manual. Considering whether the best estimate represents a mean, median or mode is useful in developing a distribution to be used subsequently in the BLCCA, such as that illustrated in Figure 2.6.

Monte Carlo Simulation

The use of Monte Carlo simulation poses a particular problem in the treatment of very rare, low-probability events. The occurrence of such events, e.g., severe storm-induced flooding, is unlikely to be sampled adequately with only 1,000 computational repetitions. For example, the probability of a 100-year storm occurring in any given year is 1 percent; the expected number of computations involving this storm over the course of simulating, for example, a 50-year planning period, is then 0.5 (i.e., 50 computation repetitions for each year at one percent probability of occurrence). However, the estimated costs incurred if the storm does occur are likely to be very large; the expected value of these storm-related costs will then be a significant factor in a BLCCA. Assessing the consequences of low-probability, high-cost events–what was termed “vulnerability costs” in Chapter 1, therefore requires either a much larger number of computational repetitions or analysis by other means than the full-scale Monte Carlo simulation used for routine costs.

Life Cycle Costing Guidelines

The Economic Analysis Concept

Technical Guidelines.

The value of an item includes not only consideration of what the costs are to acquire it, but also the cost to use it or the cost of performance to the user for as long as the user needs it. It is the user who determines value. Therefore, one measure of value to the user is to calculate the cost of ownership or use. Costs of repairs, operations, preventive maintenance, logistic support, utilities, depreciation and replacement, in addition to capital cost, all reflect on the total value of a product to a user.

Calculation of LCC for each alternative during performance of a VE study is a way to judge whether product quality is being maintained in sufficient degree to prevent degradation of necessary reliability, performance, and maintainability. The concept of economic analysis, which is used in LCC, requires that comparisons be made between things similar in nature. For example, one cannot compare the LCC of a bus to a car on a product basis, nor can one compare a house to a school on a product basis. In VE all ideas can be compared on a LCC basis if all alternatives were defined to satisfy the same basic function or set of functions.

In addition to comparable functions, economic analysis requires that alternative choices be considered on the same:

(1) Time Frame

(2) Quantities

(3) Quality Level

(4) Levels of Service

(5) Economic Conditions

(6) Market Conditions

(7) Operating Conditions

Cost Elements

In performing LCC for a VE study the emphasis is on performing a comparative estimate rather than on developing a full budget estimate over the life span. This means that the VE team should identify, and quantify, only those elements of cost that they consider statistically significant in the decision making process. The applicable cost elements will vary with the item, system, or facility being studied. However, some of the types of costs to consider fall into the following three categories.

A. Initial Costs

1. Item Cost:

   These are costs to produce or construct the item.

2. Development Cost:

   These are costs associated with design, testing, prototype, and models.

3. Implementation Cost:

   These are costs expected to occur after approval of the idea such as: redesign, inspection, testing, contract administration, training, and documentation.

4. Miscellaneous Cost:

   These costs depend on the item and include costs for owner furnished equipment, financing, licenses and fees, and other one-time expenditures.

B. Annual Recurring Costs

1. Operation Cost:

   These costs include estimated annual expenditures associated with the item such as for utilities, fuel, custodial care, insurance, taxes, other fees, and labor.

2. Maintenance Cost:

   These costs include annual expenditures for scheduled upkeep and preventative maintenance for an item to keep it in operable condition.

3. Other Recurring Costs:

   These include costs for annual use of equipment associated with an item as well as annual support costs for man agement overhead.

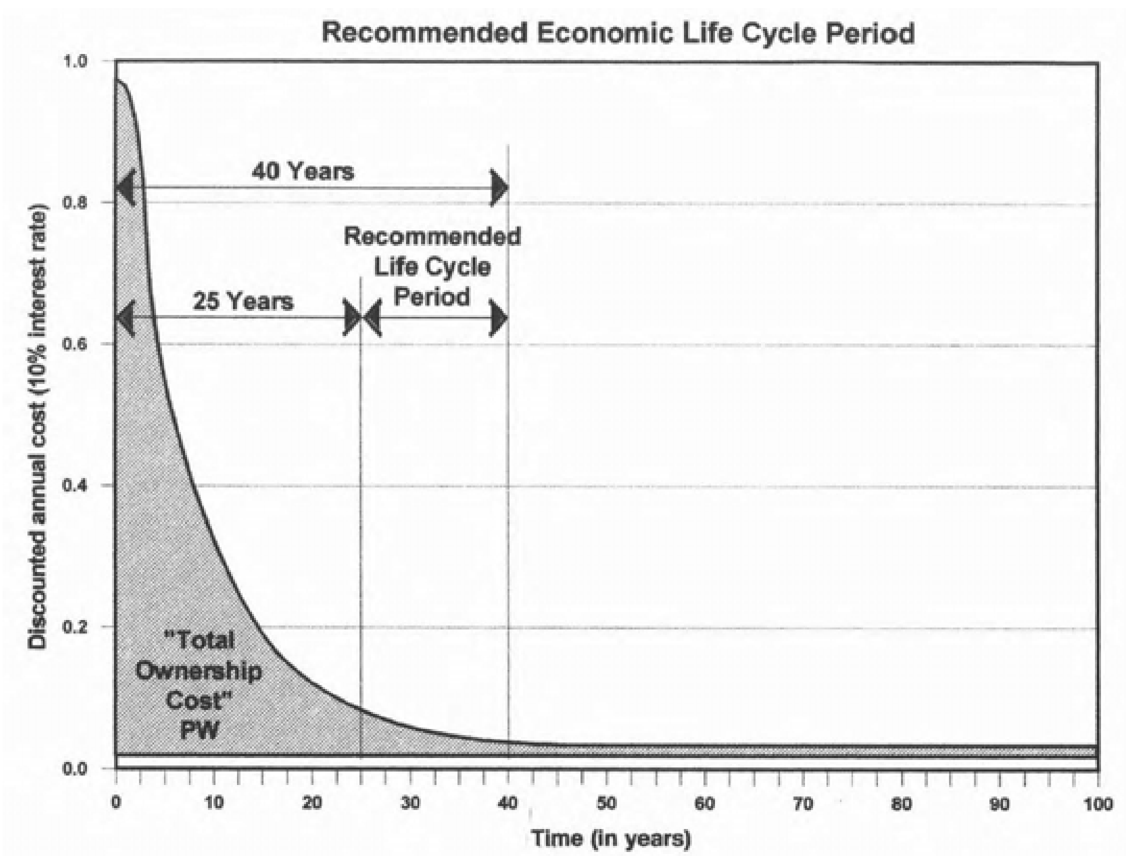
C. Nonrecurring Costs:

1. Repair and Replacement Cost:

   These are costs estimated on the basis of predicted failure and replacement of major system components, predicted alteration costs for categories of space related to the frequency of moves, and capital improvements predicted necessary to bring systems up to current standards at given points in time. Each estimated cost is for a specific year in the future.

2. Salvage:

   Salvage value is often referred to as residual value. Salvage value is an equivalent credit and is entered as a negative amount in the LCC calculation. Salvage value represents the remaining market value or use value of an item at the end of the selected LCC life span.



Recommended Approaches

The two most frequent methodologies used to calculate LCC are:

1. Present-Worth Method

GSA recommends the use of the present worth method of Life Cycle Cost Analyses of competing alternative design solutions. The present-worth method requires the conversion of all present and future expenditures to a base line of today's costs. Initial costs are already expressed in present worth. Conversion tables are to be found in most VE and LCC textbooks for converting recurring and non-recurring costs into present-worth values.

2. Impact of Escalation:

Department of Energy guidelines for escalating future cost increases for fuel will be followed. This usually will result in a 3-5 percent differential escalation rate (e.g. above general inflation) for energy.

LCC EXAMPLE

Car Purchase Input Data ($)

Cost Element	Car A	Car B	Car C
Initial cost	$16,500	$15,000	$30,000
Sales tax	5%	5%	5%
Trade-in value (5 years)	3,900	3,500	15,000
License and insurance cost/yr.	750	1,000	1,500
Maintenance and operating cost/yr.	2,200	2,800	2,000
Tire costs at 2 and 4 years	225	300	350
Major replacement at 2-1/2 years	500	750	400
Depreciation 5 years straight line			
Investment tax credit 10%			
Tax bracket of consultant 30% tax rate			

Life Cycle Costing (Annualized)

Item: *CAR PURCHASE* | Date: *N/A* | Sheet No.: *1 of 1*

☐ Others ☐ Process ☐ Mechanical ☐ Electrical

Economic Life: 5 Years | Discount Rate: 10%

	Item	Description		Original	Alternate No. 1	Alternate No. 2
Input Data	Collateral & Instant Contract Costs	**Base Costs**		*16,500*	*15,000*	*30,000*
		Interface Costs				
		a. *Sales Tax*		*825*	*750*	*1,500*
		b.				
		c.				
		Other Initial Costs				
		a. **Investment Tax Credit*		*(1,650)*	*(1,500)*	*(3,000)*
		b.				
		c.				
		Total Initial Cost Impact (IC)		*15,675*	*14,250*	*28,500*
		Initial Cost Savings				
	Salvage & Replacement Cost	**Single Expenditures 10.00% Interest**				
		Present Worth				
		1. Year *2 (Tires)*	Amount	*225*	*300*	*350*
		PW=Amount x PW factor	*0.826*	*186*	*248*	*289*
		2. Year *2.5 (Major Replac.)*	Amount	*500*	*750*	*400*
		PW = Amount x PW factor	*0.789*	*395*	*592*	*316*
		3. Year *4(Tires)*	Amount	*225*	*300*	*350*
		PW = Amount x PW factor	*0.683*	*154*	*205*	*239*
		4. Year *5 Trade-In*	Amount	*(3,900)*	*(3,500)*	*(15,000)*
		PW = Amount x PW factor	*0.620*	*(2,418)*	*(2,170)*	*(9,300)*
		5. Year	Amount			
		PW= Amount x PW factor				
		Salvage Amount x (PW Factor _____) =				
Output	Life Cycle Costs (Annualized)	**Annual Owning & Operating Costs**				
		1. Capital IC x PP	*0.2638*	*4,135*	*3,759*	*7,518*
		Recovery Years @	%			
		Replacement Cost: PP x PW				
		a. Year *2 -Tires*		*49*	*65*	*76*
		b. Year *2.5 -Major rpt*		*104*	*156*	*83*
		c. Year *4 -Tires*		*41*	*54*	*63*
		d. Year				
		e. Salvage, Year 5		*(638)*	*(572)*	*(2,453)*
		2. Annual Cost				
		a. *Maintenance & Operation*		*2,200*	*2,800*	*2,000*
		b. *Licenses & Insurance*		*750*	*1,000*	*1,500*
		c. *Depreciation Credits**		*(990)*	*(900)*	*(1,800)*
		d.				
		e.				
		3. Total Annual Cost (TAC)		*5,651*	*6,362*	*6,987*
		Annual Difference (AD)		*(1,336)*	*(625)*	
		4. PW of Annual Costs (PWA x TAC)		*21,423*	*24,118*	*26,488*
		5. PW of Annual Diff.(AD x PW	*3.971 = PWA*	*5,065*	*2,370*	

PP = Periodic Payment (periodic payment necessary to pay off loan of $1)

PWA = Present Worth of Annuity (what $1 payable periodically is worth today)

PW= Present Worth (what $1 due in the future is worth today)

*Investment tax credit assumes a 30% tax bracket, five-year **straight-line depreciation.**

Life Cycle Costing Example (PW)

Item: Car Purchase **Date:** N/A

Sheet No: 1 of 1

☐ Process ☐ Electrical ☐ Mechanical ☐ Others

Economic Life: 5 Years **Discount Rate: 10%**

Description			Original Estimated Cost	Original Present Worth	Alternate No. 1 Estimated Cost	Alternate No. 1 Present Worth	Alternate No. 2 Estimated Cost	Alternate No. 2 Present Worth
1. Initial/Collateral Costs								
A. Base Costs on Road			16,500	16,500	15,000	15,000	30,000	30,000
B. Sales Tax			825	825	750	750	1,500	1,500
C. Investment Tax Credits			(1,650)	(1,650)	(1,500)	(1,500)	(3,000)	(3,000)
D.								
E.								
F.								
G.								
Total Initial/Collateral Cost (PW)				15,675		14,250		28,500
Total Initial/Collateral Cost Savings								
2. Replacement/Salvage Costs	**Year**	**PW**						
A. *Tires*	2	0.826	225	186	300	248	350	289
B. *Major Replace.*	2.5	0.789	500	395	750	592	400	316
C. *Tires*	4	0.683	225	154	300	205	350	239
D.								
E. *Salvage*	5	0.620	(3,900)	(2,418)	(3,500)	(2,170)	(15,000)	(9,300)
F.								
G.								
H.								
Total Replacement/Salvage Costs (PW)				(1,683)		(1,125)		(8,456)
3. Annual Costs	**Dif. Escal.**	**PWA$_e$**						
A. *Operating Cost*	0	3.791	2,200	8,340	2,800	10,615	2,000	7,582
B. *License & Insur.*	0	3.791	750	2,843	7,000	3,791	1,500	5,687
C. *Dep. Credits*	0	3.791	(990)	(3,753)	(900)	(3,412)	(1,800)	(6,824)
D.								
E.								
F.								
G.								
H.								
Total Annual Cost								
Total Annual Cost (PW)				7,430		10,994		6,445
Grand Total Present Worth Costs				21,422		24,119		26,489
Life Cycle Present Worth Savings				5,067		2,370		
Savings %				23.65%		9.83%		

PW = Present Worth Factor (what $1 due in the future is worth today)
PWA = Present Worth of Annuity Factor (what $1 payable periodically is worth today)
PWA$_e$ = Present Worth of Annuity Escalating (what $1 payable periodically that is differentially escalating is worth today)
The depreciation credits column is based on 30% tax rate, straight-line five-year depreciation.

Weighted Evaluation

Project: Car Purchase | **Date:**

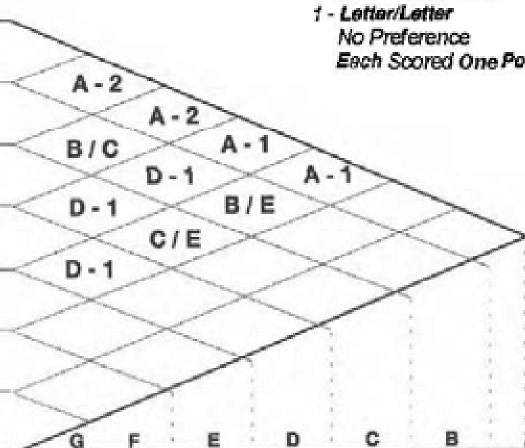
❑ Architectural ❑ Structural ❑ Mechanical ❑ Others | Sheet No: 1 of 1

Criteria
Criteria Scoring Matrix

How Important:

4 - Major Preference
3 - Above Average Preference
2 - Average Preference
1 - Slight Preference
1 - Letter/Letter
No Preference
Each Scored One Point

A. *Cost (LCC)*
B. *Appearance*
C. *Comfort*
D. *Performance*
E. *Safety*
F.
G.



Analysis Matrix
Alternatives

Alternatives	G	F	E	D	C	B	A	Total
Raw Score			2	3	2	2	6	
Weight of Importance (0 - 10)			3	5	3	3	10	
1. *Car A (Original)*			9 / 3	15 / 3	6 / 2	6 / 2	50 / 5	86*
2. *Car B (Alternative No. 1)*			9 / 3	10 / 2	12 / 4	9 / 3	40 / 4	80
3. *Car C (Alternative No. 2)*			12 / 4	25 / 5	15 / 5	15 / 5	10 / 1	77
4.								
5.								
6.								
7.								

* Selected based on weighted evaluation

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

WORK SHOPS

Value Engineering Workshop		Function Analysis	
Name/s		Date	
		Company	

Construct a function analysis worksheet for a laptop.

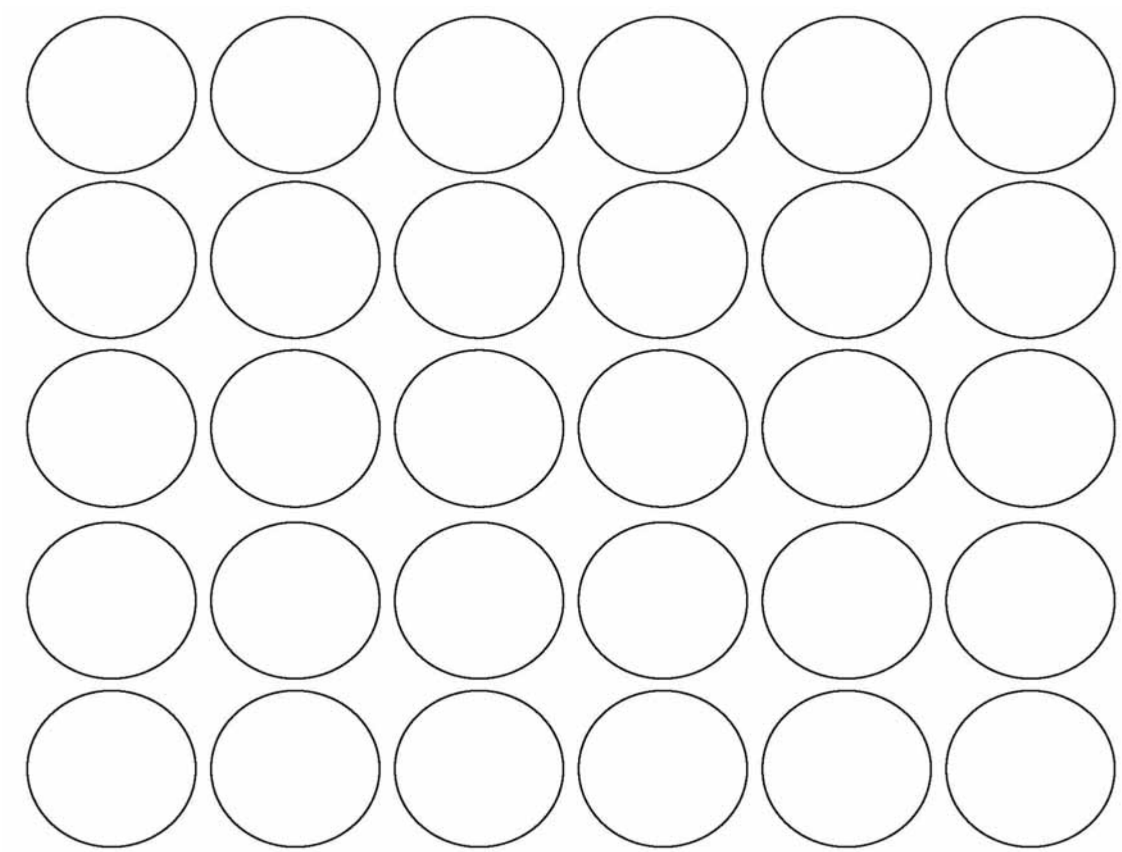
Component	Function	Function Type	Cost	Worth	$\frac{\text{Cost}}{\text{Worth}}$	Comments

Value Engineering Workshop		FAST	
Name/s		Date	
		Company	

Draw a FAST diagram for a car.

Value Engineering Workshop		Creativity (01)	
Name/s		Date	
		Company	

Fill out some of the following circles so as to generate specific figure in 200 seconds.



Value Engineering Workshop		Creativity (02)	
Name/s		Date	
		Company	

Using the following squiggle create a complete figure in 5 minutes.

Value Engineering Workshop		Decision Making (01)	
Name/s		Date	
		Company	

Allen Young has always been proud of his personal investment strategies and has done very well over the past several years. His invests primarily in the stock market. Over the past several months, however, Allen has become very concerned about the stock market as a good investment. In some cases it would have been better for Allen to have his money in a bank than in the market. During The next year Allen must decide whether to invest $10,000 in the stock market or in a certificate of deposit (CD) at an interest rate of 9%. If the market is good, Allen believes that he could get a 14% return on his money. With a fair market, he expects to get an 8% return. If the market is bad he will most likely get no return at all. Allen estimates that the probability of a good mark is 0.4, the probability of a fair market is 0.4, and the probability of a bad marker is 0.2.
Develop a decision table for this problem.
What is the best decision?

Value Engineering Workshop		Decision Making (02)	
Name/s		Date	
		Company	

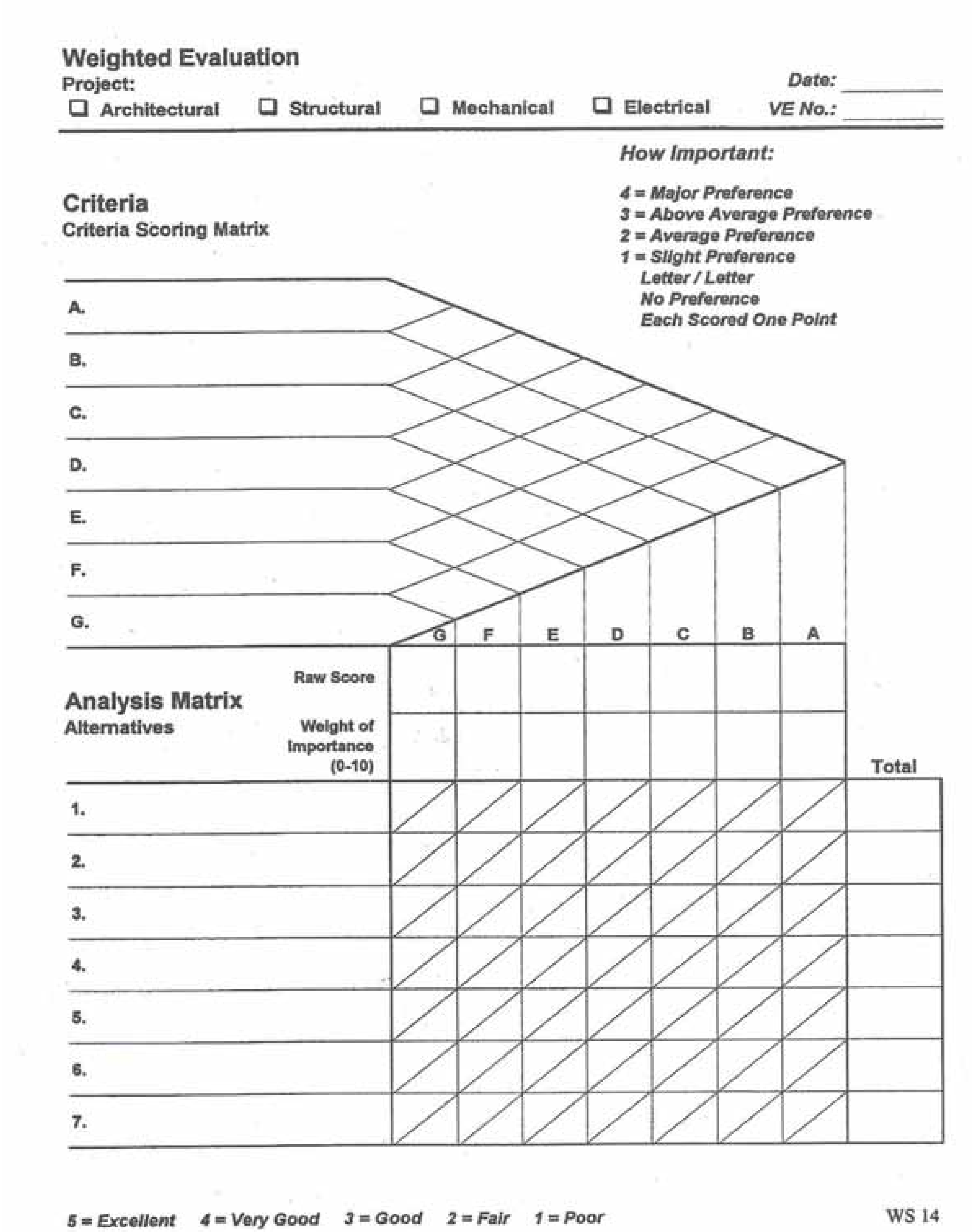
Monica Britt has enjoyed sailing small boats since she was 7 years old, when her mother started sailing with her. Today. Monica is considering the possibility of starting a company to produce small sailboats for the recreational market. Unlike other mass-produced sailboats, however, these boats will be made specifically for children between the ages of 10 and 15. The boats will be of the highest quality, and extremely stable, and the sail size will be reduced to prevent problems of capsizing.

Because of the expense involved in developing the initial molds and acquiring the necessary equipment to produce fiberglass sailboats for young children, Monica has decided to conduct a pilot study to make sure that the market for the sailboats will be adequate. She estimates that the pilot study will cost her $10,000.

Furthermore, the pilot study can be either successful or not successful. Her basic decisions are to build a large manufacturing facility, a small manufacturing facility, or no facility at all. With a favorable market, Monica can expect to make $90,000 from the large facility or $60,000 from the smaller facility. If the market is unfavorable, however, Monica estimates that she would lose $30,000 with a large facility, while she would lose only $20,000 with the small facility.

Monica estimates that the probability of a favorable market given a successful pilot study is 0.8. The probability of as unfavorable market given an unsuccessful pilot study result is estimated to be 0.9. Monica feels that there is a 50-50 chance that the pilot study will be successful. Of course, Monica could bypass the pilot study and simply make the decision as to whether to build a large plant, small plan, or no facility at all. Without doing any testing in a pilot study, she estimates that the probability of a successful market is 0.6. What do you recommend?

Value Engineering Workshop		Dual Comparison Weighing	
Name/s		Date	
		Company	



Weighted Evaluation

Project:

- ☐ Architectural ☐ Structural ☐ Mechanical ☐ Electrical

Date: __________

VE No.: __________

How Important:

4 = Major Preference
3 = Above Average Preference
2 = Average Preference
1 = Slight Preference
Letter / Letter
No Preference
Each Scored One Point

Criteria

Criteria Scoring Matrix

A.
B.
C.
D.
E.
F.
G.

	G	F	E	D	C	B	A	
Raw Score								
Weight of Importance (0-10)								Total

Analysis Matrix

Alternatives

Alternatives	G	F	E	D	C	B	A	Total
1.								
2.								
3.								
4.								
5.								
6.								
7.								

5 = Excellent *4 = Very Good* *3 = Good* *2 = Fair* *1 = Poor*

WS 14

Value Engineering Workshop		Employing VE	
Name/s		Date	
		Company	

Proposal No. ______ Date ______

PROJECT LIFE CYCLE (YEARS) ______

DISCOUNT RATE (PERCENT) ______

			Original		Alternative 1		Alternative 2		Alternative 3	
Capital Cost			Est.	PW	Est.	PW	Est.	PW	Est.	PW
A)										
B)										
C)										
D)										
Other Initial Costs										
A)										
B)										
Total Initial Cost Impact (IC)										
Initial Cost PW Savings										
Replacement/Salvage Costs	Year	Factor								
A)										
B)										
C)										
D)										
E)										
F) Salvage (neg. cash flow)										
Total Replacement/Salvage PW Costs										
Operation/Maintenance Cost	Escl. %	Factor								
A)										
B)										
C)										
D)										
E)										
Total Operation/Maintenance (PW) Costs										
Total Present Worth Life Cycle Costs										
Life Cycle (PW) Savings										

PW - Present Worth PWA - Present Worth of Annuity

WS-13

Value Engineering Workshop		Employing VE	
Name/s		Date	
		Company	

Mark all the appropriate sentences:

VE may not be employed because:

( ) We had not heard of this term before.
( ) We lacked knowledge of this technique.
( ) The owners/consultants have not recommended such service.
( ) Carrying out such a study requires extra cost.
( ) We did not consider future running cost, maximization of profit was more important.
( ) This method requires extra time for study.
( ) Good planning and management were already adopted.
( ) Feasibility is always assessed, so VE is not needed.
( ) It is not a "must".
( ) Schedule is too tight, redesign may delay the project.
( ) VE should be part of the design process.
( ) Benefits cannot be guaranteed.

VE may be employed only if:

( ) The size of the project warranted the profit.
( ) Reasonable fees are charged for carrying out this study.
( ) There are capable professionals to carry out the study.

Comments: