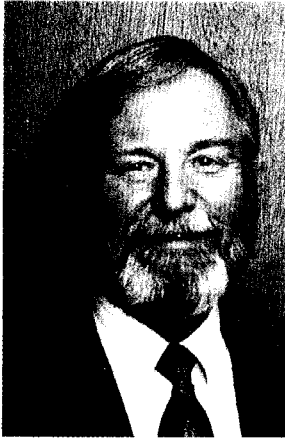


STOP COUNTING BEANS AND START REDUCING SURPRISES PRE-DESIGN VE FOR CONSTRUCTION

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ABSTRACT

Value Engineering (VE) continues to be used primarily to reduce costs during construction project design. The objective of a *pre-design* VE study is to reduce surprises when its time for the architect to present the schematic design and budget to the owner. Function Analysis, and specifically Customer FAST diagramming, is easily adapted to the problem of quickly establishing, with owner and users, accurate, reliable project requirements and budget guidelines before design starts. This paper discusses how I have been using Customer FAST diagramming to help project teams set project direction and determine the project budget.

INTRODUCTION

The power of Modern VE is its systematic approach to identifying and analyzing *functions*, what customers *Need* and *Want* to make their buildings and projects work for them. Function Analysis is the foundation of VE. It is crucial to a successful study that proposes changes to improve project value, not just reduce cost - changes which do not detract from performance or aesthetics, but enhance both. Function Analysis and FAST are commonly used to audit construction projects during various design phases. But they have an important role to play in programming as well.

Programming is the initial exercise engaged in by the architect with the client to establish specific project space needs and physical design requirements.

A well defined program contains all the information designers need to prepare project Schematic Design, the first step leading toward complete plans and specifications from which the contractor will build the project. Function Analysis and FAST help the project team create a *Function* Program, an analysis of customer *business and operational* Needs and Wants. The Function Program precedes the Design Program and clarifies how the customer will use the project. The Design Program translates the Function Program into the space and physical requirements to support the operational Needs and Wants (Functions).

In this paper, I first compare and contrast using Customer FAST to analyze a design with its use to generate project requirements before design starts. Next, I describe a VE Job Plan and study methodology based on Customer FAST which results in the project team identifying specific problems to be solved during design, typologies of appropriate design solutions, and an acceptable project budget. Finally, I tie it all together and illustrate a highly visual method for recording and displaying information discussed and decisions made during the study and which easily and quickly translates into a written report.

VE MILESTONES

Three significant milestones in the evolution of VE give it a customer focus. Together, they comprise what I call "Complete Function Analysis," and constitute the core of Modern VE. First, Larry Miles observed that people want to buy function, not parts

or systems. Miles then developed the Function Analysis method, including allocating costs to functions.

The second milestone occurred in the 1960's. Charles W. Bytheway, an engineer with Sperry Rand's Univac Division, created the Function Analysis System Technique (FAST) diagram. The FAST diagram is a structure within which and rules by which to logically diagram the relationship of Miles' functions. Perhaps Bytheway was influenced by the introduction and popularity of Critical Path Method and PERT charts as project management tools. Bytheway used his diagrams to promote and reinforce the creative process of finding alternatives to performing functions. (C.W. Bytheway, "FAST - An Intuitive Thinking Technique," 1992 *SAVE Proceedings*, p. 229 - 232.)

FAST diagramming was developing parallel with thinking about how to define poor value and pinpoint non-required functions. The Technical FAST diagram evolved from Bytheway's original diagrams. Functions could be diagrammed and costed and a Value Index calculated. The basic methodology was powerful, but presumed that the question, "Which functions give good value and which functions give poor value?" could be answered by the VE study team. Because the team was composed of engineers, it usually answered this question from an engineering and design perspective. The hypothesis was that value could best be improved by reducing cost.

The third milestone was reached as business and industry became more tuned to their customers' needs. It soon became clear that a mechanism to have the customers, not the engineers, identify required and poor value functions was desirable. In the 1970's, Thomas J. Snodgrass, a consultant and professor teaching VE at the University of Wisconsin, devised a market research based technique to compare how important *customers* think functions are with the cost of the functions.

Thomas M. Cook, also a VE consultant, simplified and modified Snodgrass' rigorous, data based methodology. Following Cook's method attitudes about what makes a successful project are collected from customers in a focus group. The team assigns the customer attitudes to functions which the team agrees the functions relate to. The function costs and customer attitudes about function importance are compared to identify value mis-matches, defined as functions for which the cost, whether high or low,

are opposite to the customers' attitudes about their importance. In the Creative Phase, the VE study team focuses its energy on identifying alternative ways to perform the mis-matched functions.

IDENTIFYING VALUE MIS-MATCHES

FUNCTION COST	FUNCTION IMPORTANCE
HIGH	HIGH
HIGH	LOW
LOW	HIGH
LOW	LOW

The obvious Value Mis-match: High function cost and low function importance. A potential Mis-match: Low function cost and high function importance if the function is not performed well. If the function is performed well, then it is good value! High function cost and high function importance indicates that if the team wants to find alternatives for performing the function, they must not degrade function performance!

After the question, "What *does* it do?" Snodgrass inserted, "What *must* it do?" with the answer supplied by the customer. Identifying and diagramming functions, costing functions and assigning customer attitudes to functions, allows the VE team to focus on the problem of balancing performance and cost, as opposed to just reducing cost. The results are changes appropriate to the customers' expectations and requirements. The method works equally well to study existing manufactured products, services and construction projects during design.

The Customer Attitude Survey

My VE Studies follow a five step Job Plan, consisting of Information, Creative, Evaluation, Development and Presentation Phases. The first Information Phase activity is a Customer Attitude Survey, a three to four hour "focus group" of customers and design and construction professionals directly engaged in the use, design, delivery, maintenance and operations of the project. Most of these people will not be VE study team members. Participants define their acceptance criteria - the desired features and characteristics and the faults and problems to be avoided - and then vote on their relative importance to each other within each group. The VE study team uses this information to identify value mis-matches. The vertical structure of the

Customer or Task FAST Diagram developed by Snodgrass allows the side-by side display of functions, their cost and customer attitudes.

column list functions describing how to build the project.

Figure 1. Partial List of Basic Functions From a Medical Center Customer FAST Design Including Function Costs and Customer Attitudes

HOW ? →		← WHY?					
TASK OR MISSION	PRIMARY LEVEL BASIC FUNCTIONS	SECONDARY LEVEL BASIC FUNCTIONS	FUNCTION COST		CUSTOMER ATTITUDES		
			\$ 000	% OF TOTAL	FEATURES AND CHARACTERISTICS	FAULTS AND COMPLAINTS	
MANAGE CARE			90,386	100			
	1 ROUTE PATIENTS	11 SCHEDULE PATIENT	1,013	1.1	3-9R4 19-10R0	3-9R4 5-5R4 6-6R5 7-6R3 9-6R6 12-4R7 13-3R6 16-10R2	
		12 REGISTER PATIENT	1,260	1.4	3-9R4 19-10R0	3-9R4 5-5R4 6-6R5 7-6R3 9-6R6 12-4R7 13-3R6 16-10R2	
		13 TRIAGE PATIENT	1,245	1.4	1-9R4 19-10R0	5-5R4 6-6R5 7-6R3 12-4R7 16-10R2	
		14 CIRCULATE PEOPLE	6,800	7.5	1-9R4 3-9R4 5-9R7 8-6R3 19-10R0	2-9R4 5-5R4 6-6R5 7-6R3 8-10R4 9-6R6 11-6R7 12-4R7 13-3R6 15-6R5 16-10R2	
	2 DIAGNOSE PROBLEM			7,855	8.6	1-9R4 2-8R5 3-9R4 15-8R4 19-10R0	3-9R4 6-6R5 7-6R3 8-10R4 12-4R7 16-10R2
	3 TREAT PROBLEM	31 MONITOR PATIENT	5,694	6.3	1-9R4 2-8R5 3-9R4 15-8R9 19-10R0	3-9R4 4-8R5 6-6R5 7-6R3 8-10R4 9-6R6 16-10R2	
		32 RECUPERATE PATIENT	8,192	9.0	1-9R4 2-8R5 3-9R4 15-8R9 19-10R0	3-9R4 4-8R5 6-6R5 8-10R4 9-6R6 16-10R2	
		33 PERFORM THERAPY	7,352	8.1	1-9R4 2-8R5 3-9R4 15-8R9 19-10R0	3-9R4 6-6R5 7-6R3 8-10R4 16-10R2	
		34 PRESCRIBE MEDICATION	2,741	3.0	1-9R4 2-8R5 3-9R4 15-8R9 19-10R0	3-9R4 6-6R5 7-6R3 16-10R2	
		35 PERFORM SURGERY	7,498	8.2	1-9R4 2-8R5 3-9R4 15-8R9 19-10R0	2-9R4 6-6R5 7-6R3 8-10R4 10-6R7 12-4R7	

Customer Centered Function Analysis

A VE study helps customers (owner and users) identify and articulate their expectations and requirements either as a prelude to programming a project, or as an audit of the design. To accomplish either, functions are defined in terms of the business and operational issues driving the project - why the project is being built, not how it will be constructed. Design solutions appropriate to supporting these issues can be generated and costed (*pre-design* VE studies) or costs analyzed to see how money is being spent through the building to achieve them (*during design* VE studies). Below are sample lists of random Business Focused and Construction Focused functions. The left hand column contains functions describing what people do in a facility. The right hand

Business Focused Functions	Construction Focused Functions
Schedule Visit	Enclose Space
Display Expertise	Support Load
Track Distribution	Control Environment
Project Competence	Distribute Power
Access Records	Condition Space
Diagnose Problem	House Controls
Analyze Results	Dewater Excavation

Construction costs assigned to business and operational focused functions, like those in the left hand column, produce a true picture of brick and mortar costs to support how the customer will use the building. Customers either assume that functions in

the right hand column will be performed or they do not even consider them. An owner does not ask an architect to construct a building that will Support Load and Distribute Power! Assigning estimated construction costs to functions such as these is usually a meaningless exercise that results in a recap of the estimate and produces no useful information for the customer to use in determining whether value for money is being received. Customers and their architects respond favorably to the display of business related functions and their costs. Final proposals always include a mixture of engineering, construction, business and operations recommendations.

VE BEFORE DESIGN: FORMULATING THE SYSTEM

One Success May Not Lead to Another!

In the 1980's I began to develop Customer FAST based methods to assist early project decision making and to establish or validate project requirements (the program) and budgets. A problem quickly developed. I could collect Customer Attitudes and the VE team could define functions and construct a FAST diagram. However no design had been completed and there was no cost estimate to allocate to the functions. I proposed that the VE team could establish baseline costs for functions by applying their creative and technical ability to identify acceptable alternatives for performing functions. I was trying to adapt the VE process I had been using for ten years to study projects during Design Development to much earlier applications. It worked successfully - once.

I facilitated a three day study which turned out extremely well. When I tried to replicate the process, it failed miserably. The team (in-house staff plus external architect) was to formulate design criteria and build a budget to expand a manufacturing plant. They produced an excellent FAST diagram. At the end of the first day, the team was having great difficulty generating ideas on performing functions and costing the ideas. And this had worked so well in the previous study! A searching conversation at dinner with my CVS co-facilitator only reinforced the observation that we and the team were stuck! (Only the team had not quite realized it!) I was ready to sneak away in the middle of the night!

I lay in bed staring at the ceiling and worrying about what to do the next morning. I turned the VE process over and over in my mind. About two o'clock in the morning the solution popped into my consciousness. I made some quick notes and fell

asleep. At breakfast I briefed my colleague on what we were going to ask the team to do, which required throwing out the previous afternoon's work! When we met the team, I admitted to the difficulties, suggesting a different approach was necessary. (Without telling the team that it would be the first time I had tried it!) It worked, and is now the basis for all of the pre-design or early design VE studies I do.

Trust The System, But Be Flexible!

I realized that the first pre-design study worked well because the required functions were highly technical in nature and readily lent themselves to engineering solutions. The functions defined for the manufacturing plant were more people management and business objectives oriented. It was also evident that their occurrence or repetition was desirable in many areas of the building. The team could not focus. The methodology I worked out overcame the problem by having the team construct a matrix on which it assigned functions from the diagram to specific activities in the building for which space would be designed. This generated a list of function design criteria for the spaces required to support activities relevant to the business of owning and operating the plant. I built upon what I already knew was useful and valid to the VE study team, the Customer FAST Diagram. But then I changed what the team did with the functions by using them as design criteria.

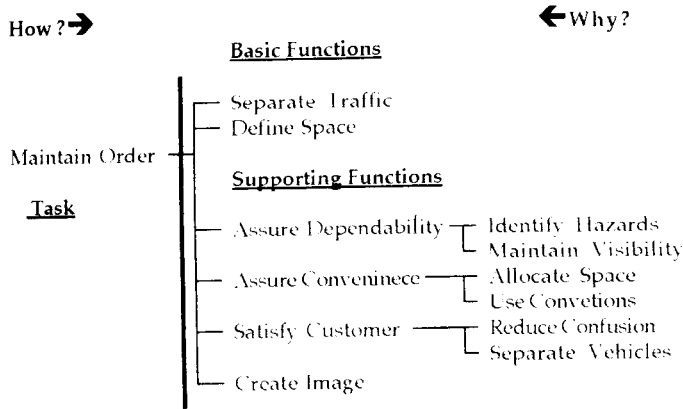
The architect and the team generated design ideas for each space which met the function design criteria for that space. The team discussed the ideas indicating their acceptance or rejection. Finally, the ideas were costed and a project budget built. The architect returned to his office with specific knowledge of what his client liked and a cost target to meet. The resulting schematic design met the customers' requirements and was within the budget target.

How It Works

A simple illustration project for marking a restaurant parking lot pavement demonstrates the methodology. In the Information Phase, the team first lists the customers and the activities they will engage in. (e.g. Patrons: driving, eating, walk through lot. Employees: Driving, walk through lot, take breaks. Deliveries: driving, unloading vehicles. Trash haulers: Driving, loading trash.) The team also discusses the numbers and frequency of vehicles,

types of vehicles, numbers of potential customers, what kinds of trash, what kinds of deliveries - project background information - which is all recorded. Next the team makes a list of parking lot elements to design markings for - Parking spaces, Sidewalks, Driveways, Aisles. Following this information gathering, the team constructs a Customer FAST Diagram of functions to be achieved by marking the pavement. (Figure 2.)

Figure 2. Customer FAST Diagram, Parking Lot Pavement Striping



After completing the FAST diagram, the team builds its matrix listing functions down the left hand side and elements to be designed across the top. The team then decides which functions to assign to which elements. (Figure 3.) Reading down the column under each element generates a list of function performance design criteria for each element. The team then generates concepts on how to accomplish the functions for each element.

Reading down the column under the element "Parking Spaces," shows the functions Define Space, Maintain Visibility, Allocate Space and Separate Vehicles, as the functions to be satisfied when the Parking Space Markings are designed. One idea which accomplishes these functions is painting stripes to mark the width of each space. A second idea is to paint a wide stripe in a continuous line to define the back edge of the spaces and paint large circles on the line to define the width of each space. A third idea is to drive small logs on end into the ground between parking space, leaving about 4-inches protruding above the surface. (We have all seen the first solution. I have seen the second and third - the last one in a wilderness area parking lot in Scotland!) These concepts can be discussed, evaluated, roughly costed and accepted or rejected in the study. The

designer refines the accepted ideas during Schematic Design.

Figure 3. Function to Element Allocation

FUNCTIONS	ELEMENTS		
	PARKING SPACES	WALKWAYS	AISLES
Separate Traffic			●
Define Space	●	●	
Identify Hazards		●	●
Maintain Visibility	●	●	
Allocate Space	●	●	
Use Conventions			●
Reduce Confusion		●	
Separate Vehicles	●		

VE During Design vs. Pre-Design: Recap

VE studies during design require the team to 1) construct a Customer FAST diagram, 2) allocate costs to functions, 3) assign customer attitudes to functions, and 4) compare function costs and customer function attitudes about function importance to identify value mis-matches, poor value functions, whether high function cost or low function cost. During pre-design VE studies, the team assigns the functions from its Customer FAST diagram to create design criteria for each space, activity or element of the project. The list of functions for each of these establishes the design problem to be solved by the architect or engineer.

VE BEFORE DESIGN: THE METHOD

The Pre-Design VE Job Plan

The Pre-design VE Job Plan follows the normal Information, Creative, Evaluation, Development and Presentation phases. The Creative, Evaluation and Development phases usually run together and are iterative rather than linear. This stimulates team member interaction, makes for a lively study and

focuses team attention on selecting ideas for designers to develop.

PRE-DESIGN VE JOB PLAN

- Information Gathering
 - Review Project and Team Goals
 - Review Project Background Information
 - Construct FAST Diagram
 - Allocate Functions to Spaces/Elements
- Generate Design Concepts by Function
- Evaluate Concepts
- Develop Recommendations
- Present Recommendations

The pre-design study is usually carried out over three consecutive days by a team of project stake holders, with heavy emphasis on owner and various users participation. It is very important to the success of the study that team members represent major project users and include a designer (architect or engineer as appropriate) and cost estimator. The primary purpose of the study is to improve communications inside the client organization as well as to the outside. The users formulate, gain insight into and articulate their requirements to the architect. In turn the architect shares his/her creative ideas, and the rough costs of those ideas, to meet the requirements. Give and take discussions occur and are encouraged.

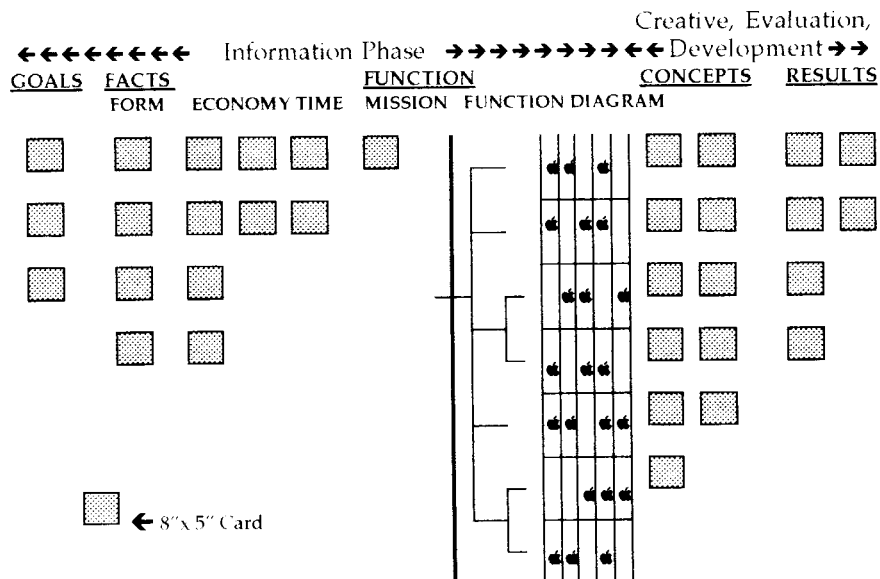
Displaying the Information

As the team progresses through the study, goals, project information, concepts and ideas, potential problems and results, are recorded by myself, an assistant or any team member on 8-inch by 5-inch cards which are posted on the wall under the headings Goals, Facts (Form, Economy, Time and Function), Concepts, Problems and Results (Figure 4.) Goals and Facts precede the Function Analysis (FAST Diagram and matrix.) Concepts, Problems and Results cards are usually created after the Function Analysis is completed, although they can be created and posted at any time. The cards are a highly visible and constant reminder of study progress and information. They may be moved from one category to another as the team sees fit and serve as visual aids during the final presentation. The cards are reproduced in the final report, and with a minimum of additional text, can serve as the complete study report.

Origin of the Card System

This system of recording project information and ideas on 8-inch by 5-inch cards and displaying them on the wall, originated with the architectural firm of Caudill Rowlett Scott (later CRSS). Under the guidance of Willie Peña, they were more fully developed as the foundation for the programming methodology used by that firm that later evolved

Figure 4. Order of Cards and Function Analysis on the Wall During Study



into CRSS Architects. The entire system developed at CRSS is fully explained in the book, "Problem Seeking: An Architectural Programming Primer," published by the American Institute of Architect's Press.

I had been intrigued for some time by the CRSS programming method because of its logical organization of information and the way it is displayed for all participants to see while the work progresses. The system clearly communicates what people are thinking and doing. The progression of the programming study closely parallels the VE Job Plan. Studying the book I became convinced that Function Analysis and FAST Diagramming could be combined with these methods. With a colleague from England, I visited CRSS' Houston headquarters in 1992 and spent one-and-a-half days with a top programmer and Willie Peña, both of whom gave generously of their time to explain the process. After the visit to Houston, I adapted CRSS' "Information Index," the collection and display of data on cards under four principal headings, Function, Form, Economy and Time, (*Ibid.* p. 28) to pre-design VE studies. The cards replace the sheets of flip chart paper on which teams record information and ideas.

Integrating FAST and the Card System

"Problem Seeking" states, "Function implies 'what's going to happen in their building,'" (*Ibid.* p. 30) mirroring my view that the functions defined

during a VE study should reflect project business and operational issues important to the customer! The perfect place to use the Customer FAST diagram! I surround the Customer FAST Diagram and accompanying matrix for assigning functions to project elements (Function), with the CRSS cards recording the Goals, Facts (Form, Economy and Time), and Concepts, Problems and Results generated by the team. The outcome is a pre-design effort thoroughly grounded in Function Analysis and FAST, that follows the VE Job Plan and displays the team's work and results in a highly graphic and visual manner. And makes the presentation a snap.

CONCLUSION

The integration of Function Analysis and FAST with the card display makes an exciting and graphic pre-design VE study. The cards help team members continually review their progress and visualize results. Quick evaluation of the ideas displayed before the entire team is possible. Developing ideas into concepts, and noting specific problems for the architect or designer to resolve, speeds the design process. A design direction is established and costs can be estimated for specific quality levels of construction focusing the architect's effort and giving the customer information required to help build or meet the project budget.