VALUE ANALYSIS OF THE CONSTRUCTION DOCUMENTS PROCESS

Eric Meng, CVS, AIA
Meng Associates Inc.
Seattle, WA 98121

Eric Meng is Principal Architect in the architecture, engineering, and planning firm Meng Associates. The firm specializes in the design of complex public facilities including educational, research, and recreational facilities. Meng Analysis is the Value Engineering (VE), quality assurance, and construction research affiliate of Meng Associates. Eric Meng has led over 175 VE studies, including buildings, transportation projects, utility facilities, waterfront facilities, construction products, management systems, and environmental remediation projects. He is particularly interested in the application of VE as a design tool; he recently presented a paper on this topic at the European VE Conference in Seville. He is President of the Seattle SAVE chapter.

ABSTRACT

This paper describes a value analysis (VA) case study conducted on the construction documents process (CDs) for large public construction projects. The study applied traditional VA techniques to reduce the design and construction costs of construction documents and to demonstrate the validity of formal VE/VA as a management tool in this process.

INTRODUCTION

The construction documents phase for contemporary public construction projects is increasingly complex and costly. This paper describes a three day VE study to reduce design and production costs, while improving the value of the construction documents.

Most architects and engineers put a great deal of thought and planning into what they design, but relatively little thought and planning into how they design. Increasingly, architects and engineers are recognizing VE as a way to improve the facilities they are designing, but few recognize that VA can also improve the way they are designing. The study described here had, as its second purpose, exploring and demonstrating the use of formal VE as a management tool for the design team.

SCOPE

The scope of the study was intended to include all tasks and documents normally included in the traditional construction documents phase of a public construction project; including drawings, specifications, and project manuals, as well as project management tasks and tools. All disciplines were to be included. In organizing the study, the VE team decided that the scope of the demonstration study would have to be limited to the architectural documents, but that the processes developed in this study whould apply to the entire scope, and for all disciplines.

VE TEAM

The nine-person study team included a team leader (Certified Value Specialist [CVS] and architect), a principal architect. two project managers, a cost estimator, a construction manager, a quality control review architect, a Computer Aided Design & Drafting (CADD) manager, and the A&E firm's business manager. Half of these individuals were from the firm sponsoring the study, and the other half from independent firms. The team members were chosen because of their experience with production technology, and their experience in building and construction. Seven of the team members had served on design and construction VE studies, and two of the team members had formal VE training (40 hour training workshops). During the first hour of the study, the team leader gave a brief orientation of VE technology. Specifically this included: the concept of value vs. worth; the definition and use of functions; the VE workplan; and creativity techniques and attitude.

WORK PLAN

The study followed a traditional five step workplan, thereby encouraging an efficient, oraganized, and comprehensive review of the project.

INFORMATION PHASE

Prior to the study, a database was prepared and modeled. Time records had been kept for the design of a recent new public school. Time for each document was listed and graphed as a percentage of the total. These were compared to other industry standards and adjusted to represent a typical model. (Fig. 1.) In addition, non-document tasks were listed and graphed. It was anticipated that many tasks completed during the construction document phase were interrelated with those of the construction phase, so these were also illustrated as a frame of reference.

LABOR ANALYSIS--MADRONA/GREGORY ELEMENTARY SCHOOLS

CONSTRUCTION DOCUMENTS EFFORTS

DWG	*TASK--DRAWING RELATED*					
#	DESCRIPTION	HRS	%	FUNCTION I	FUNCTION II	FUNCTION III
1	Sheet Index	10	0.55%	Coordinate Drawings	Identify Symbols	
2	Cover	3	0.16%	Locate Project	Identity Designers	
3	Site Development	76	4.15%	Locate Buildings		
5	Site Details and Plan	67	3.66%	Locate Site Features	Define Site Features	
6	Key Plan	3	0.16%	Coordinate Drawings	Identify Area Separation	
7	Floor Plans	164	8.95%	Locate Partitions	Identify Spaces	Locate Doors
8	Enlarged Plans	187	10.21%	Coordinate components	Locate Casework	Locate Fixtures
9	Attic Plan	23	1.26%	Locate Partitions	Locate Doors	
10	Roof Plan	24	1.31%	Define Roof Shape	Locate Roof Accessories	Identify Roof Components
11	Room Finish Schedule	40	2.18%	Identify Finishes		
12	Door Schedule and Types	49	2.67%	Define Doors/Frames	Quantify Doors	
12	Door Details	65	3.55%	Define Frames at Walls		
14	Wall Types and Details	67	3.66%	Define Walls Types	Define Shape	Locate Windows
15	Building Elevations	172	9.39%	Locate Exterior Finishes	Locate Connections	Define Connections
16	Building Sections	93	5.08%	Locate Structure	Quantify Windows	
17	Window and Louver Schedule	34	1.86%	Define Windows		
18	Window and Louver Details	27	1.47%	Define Frame Installation	Define Casework	
19	Interior Elevations	198	10.81%	Locate Finishes	Coordinate Mech/Elec	
21	Reflected Ceiling Plans	95	5.19%	Locate Ceilings		
22	Stairs, Ramps and Details	80	4.37%	Define Stairs		
23	Elevator Plan and Section	40	2.18%	Define Elevators		
24	Exterior Wall Schedule	123	6.71%	Define Walls		
25	Miscellaneous Details	14	0.76%	Define Components		
26	2-Hour Separation Walls	33	1.80%	Meet Code		
27	Special Details	105	5.73%	Define Components		
28	Casework	40	2.18%	Define Casework		
	TOTAL	1832	100.00%			

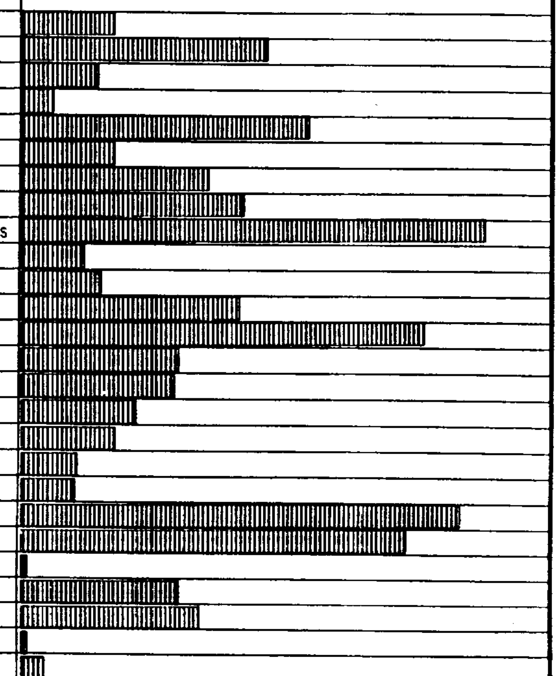

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Figure 1

FUNCTIONAL

A Functional Analysis diagram was completed to define the primary and essential and non-essential functions of the CDs. Noting that many activities in the CD phase overlap or refine those in the other design and construction phases, the Functional Analysis diagram (Fig. 2) illustrated the relationship of the CDs to the other design phases and to the higher order functions of the project, ultimately "to educate students." This was to serve as a reminder to the VE team to search beyond the project scope for solutions and to carefully evaluate whether a function is essential or non-essential. The outline of the Functional Analysis diagram was prepared by the team leader before the study, but the quality or criteria functions were added to the Functional Analysis diagram by the study team at the beginning of the study.

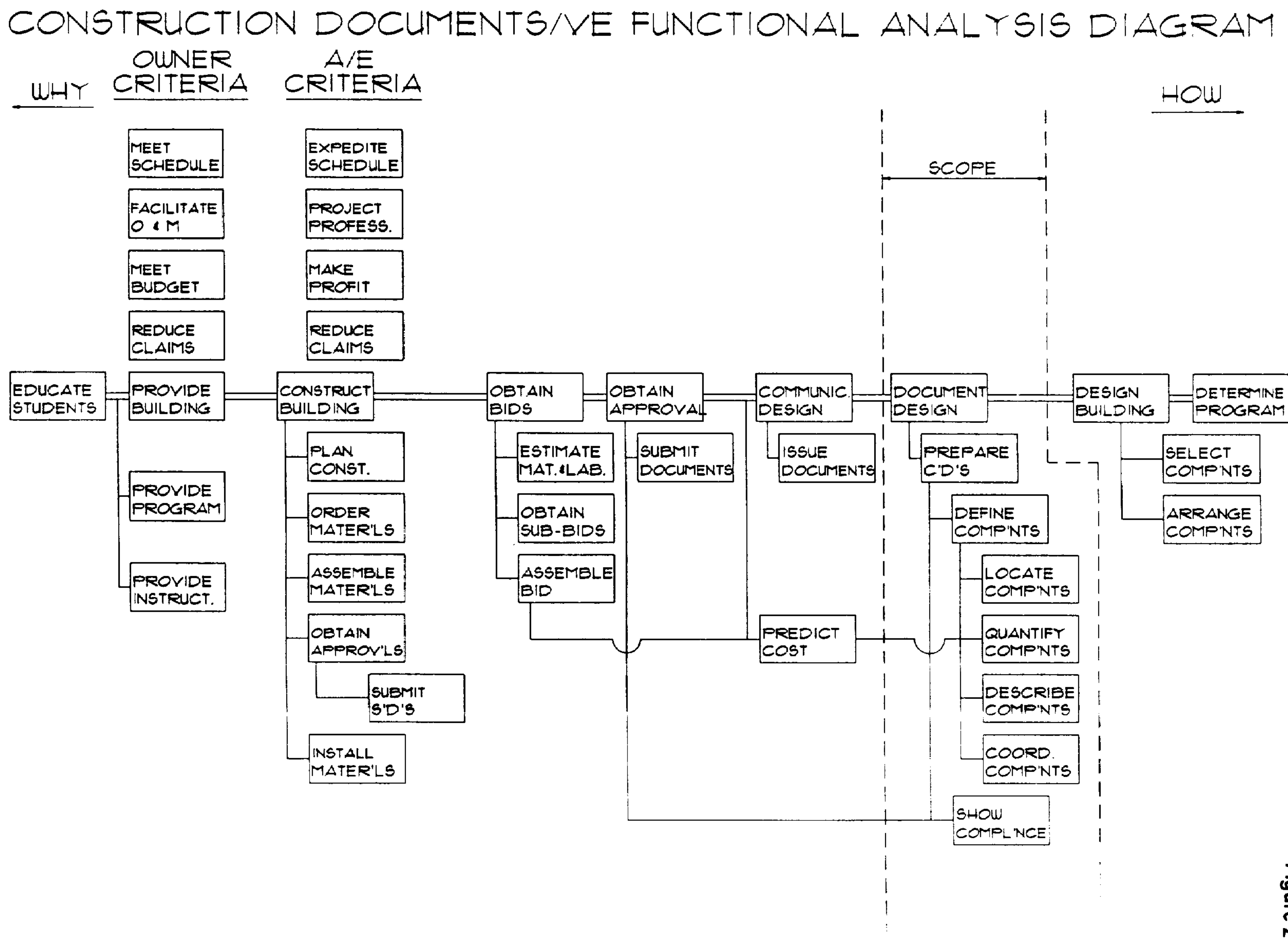
CONSTRUCTION DOCUMENTS/VE FUNCTIONAL ANALYSIS DIAGRAM
WHY
OWNER CRITERIA
A/E CRITERIA
HOW
MEET SCHEDULE
FACILITATE O & M
MEET BUDGET
REDUCE CLAIMS
EXPEDITE SCHEDULE
PROJECT PROFESS.
MAKE PROFIT
REDUCE CLAIMS
SCOPE
EDUCATE STUDENTS
PROVIDE BUILDING
CONSTRUCT BUILDING
OBTAIN BIDS
OBTAIN APPROVAL
COMMUNIC. DESIGN
DOCUMENT DESIGN
DESIGN BUILDING
DETERMINE PROGRAM
PROVIDE PROGRAM
PROVIDE INSTRUCT.
PLAN CONST.
ORDER MATER'LS
ASSEMBLE MATER'LS
OBTAIN APPROV'LS
SUBMIT S'D'S
INSTALL MATER'LS
ESTIMATE MAT.&LAB.
OBTAIN SUB-BIDS
ASSEMBLE BID
SUBMIT DOCUMENTS
ISSUE DOCUMENTS
PREDICT COST
PREPARE C'D'S
DEFINE COMP'NTS
LOCATE COMP'NTS
QUANTIFY COMP'NTS
DESCRIBE COMP'NTS
COORD. COMP'NTS
SHOW COMPL'NCE
SELECT COMP'NTS
ARRANGE COMP'NTS

Figure 2

The Functional Analysis diagram illustrated that the essential functions are repeated and applied to each of the project building components. In other words, the "Why" function "define components" needs to be repeated as "define roofing." "define floor structure," "define doors." etc., and the "How" functions "locate component," "quantify component," "describe component," and "attach component" need to be applied to the roofing components, structural components, doors, etc. The function "show compliance" was identified as an essential function since there are specific documents and methods of documentation required by code officials to obtain permits. The quality functions or criteria functions were identified as: control costs, expedite schedule, project professionalism, facilitate O & M, reduce claims, and make profit. (See Fig 2)

After the initial definition of functions, the project components were distributed amongst the team members. Using the function/worth worksheet, (Fig. 3) the components were identified, and for each component, the functions and worth were listed. This worth was based on a quick, subjective analysis by an individual team member based on his/her expeience. The total cost vs. the total worth for each main component was then calculated and listed on the summary sheet. (Fig. 4)

COMPONENT WORKSHEET COST - FUNCTION - WORTH: INTERIOR ELEVATIONS

Figure 3

COMPONENT/TASK	LOCATE FINISHES	DEFINE CASEWORK	LOCATE ACCESSORIES	DEFINE RELITES	LOCATE EQUIP.	LOCATE ELEC. DEVICES	LOCATE DETAILS	QUANTIFY COMPONENTS	DEMONSTRATE CODE COMPLIANCE	PROJECT QUALITY IMAGE	
	PRIMARY							SECONDARY			
INTERIOR ELEVATIONS		310 HRS / 16.94 %									
	COST										WORTH
SUBCATEGORY											
CLASSROOM ELEV.		●	o	●	o	o	o	o		o	26
MULTI-MEDIA ELEV.		●	o	●		o	o	o			8
TOILET RM. ELEV.	●		●		o	o	o	o	●	o	14
MISC. RM. ELEV.		●	o	●		o		o			12
SPEC. CLSRM ELEV.		●	o	●		o	o	o		o	8
ADMIN. ELEV.		●	o	●	o	o	o	o		o	12
KITCHEN ELEV.			o	●	o	o		o	●		8
MUSIC /STAGE ELEV.	●	●	o	●	o	o	o	o			4
MULTI-PURPOSE RM. ELEV.				●	●	o	o	o			16
GYMNASIUM ELEV.				●	●	o	o	o	●		14
LIBRARY ELEV.		●		●		o				o	26
CORRIDOR ELEV.	●			●		o	o				26
											150

o FUNCTION REPEATED ELSEWHERE

● FUNCTION NOT REPEATED ELSEWHERE

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Figure 4

PROJECT Construction Documents VE DATE February 1993

Value Factor / Cost Rank	Assigned	COMPONENT	WORTH (Hrs.)	$ (Hrs.) CURRENT	$ (Hrs) VE	$ (Hrs.) ▲
.1	JB	Sheet Index	2	20	10	10
.4	JB	Cover	4	10	6	4
.7	TB	Site Development	50	76	55	21
.9 6	TB	Site Details	60	67	60	7
0	JB	Key Plan	0	10	4	6
.8 3	SM	Floor Plans	160	190	290	(100)
.5 10	SM	Enlarged Plans	40	75	12	63
.9	SM	Attic Plan	20	23	20	3
.8	DE	Roof Plans	20	24	20	4
.7	SM	Room Finish Schedule	30	40	36	4
.9	NP	Door Schedules	43	49	49	0
.3 9	NP	Door Details	20	65	24	41
.3	NP	Wall Types	20	67	20	27
.7 2	JB	Building Elevation	116	172	120	52
.9 8	JB	Building Section	80	93	80	13
.5	JO	Window/Louver	30	61	40	21
.5 1	DE	Interior Elevations	150	310	40	270
.8 7	TB	Reflective Ceiling	75	95	80	15
.8 11	JB	Stairs Ramps/Details	60	80	40	40
.1	TB	Elevation Plans	40	40	40	0
.8 4	JB	Exterior Wall Sections	100	123	110	13
.7	DE	Details	10	14	10	4
.7	DE	2 Hr. Separation Walls	24	33	20	13
.4 5	JO	Miscellaneous Spec. Details	40	105	75	30
.3	NP	Casework	12	40	12	28
		TOTAL:				589

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To prioritize the team's work, the components were rated in order of highest cost and in order of highest value factor (value factor equals the worth divided by the costs). From this summary, the team decided to focus first on the building interior elevations, the building plans, and the exterior wall sections, since these components all had the highest component costs and reatively low value ratios.

SPECULATION PHASE

During the speculation phase the following questions were asked for each component and subcomponent:

1. Is this function duplicated elsewhere? Can duplication be reduced?
2. Can this function be combined with others?
3. Can the function be performed by others? (e.g. consultant, agency, manufacturer, contractor, owner)
4. Is this a nonessential function? Can this function be eliminated?
5. How else can this function be performed?

Non-judgemental ideas were solicited in a freewheeling group session and listed on the large creativity sheets.

ANALYSIS PHASE

During the analysis session, each team member was given two first place and two second place votes and asked to select their preferred ideas, keeping in mind the required functions, secondary functions, and quality criteria functions. They voted by placing colored dots next to the preferred ideas. Graphically, this clearly illustrated which ideas warranted further attention. All those ideas that did not recieve votes were quickly reviewed to assure that everyone was willing to reject them from further consideration. All ideas that did receive any votes were evaluated with a quick pro con discussion. Those that received the highest first and second place votes were evaluated using the criteria matrix. Here the quality functions were included in the matrix. These functions were also weighted using a criteria weighting matrix.

DEVELOPMENT PHASE

During the development phase, two or three ideas for each component were further developed with more detailed cost estimation. Where negative aspects had been identified, an attempt was made to reduce the negative ramifications. Typically, this meant substituting activities or documents in other component areas and adding some cost back into the project. Some of the ideas that were originally identified as potential cost reduction ideas actually became more expensive. Some of these were then rejected but some were considered simply because of the difference of approach.

IMPLEMENTATION PHASE

The design firm that sponsored this study decided that most of the developed ideas were worthy of implementation, but to reduce risk and to gain acceptance from the production department, they decided to implement only one or two separate ideas in each of their next projects. They will track carefully the cost as well as the relative success in meeting the quality functions.

Since the study was limited in time and scope, the VE team decided to follow it up with a series of future sessions, each one focusing on one of the remaining components and the non-document tasks. These future sessions will maintain the same core team, but will introduce other design, construction, and management people to the team to gain additional perspective and to introduce the benefits of VE to more professionals.

CONCLUSIONS

Since this study had two different major objectives, there are two separate sets of conclusions. The first is in the study topic itself, namely construction documents, and the second is in the VE process used for the study.

CONSTRUCTION DOCUMENTS OBSERVATIONS AND CONCLUSIONS

There are tremendous opportunities for reducing the cost of traditional construction documents. By defining very carefully the function of each detail, much drawing and production can be eliminated when the focus is only on the minimum area needed to define the future component. There are many non-traditional methods available to define building components. This study indicated that the development and use of more symbolic notation is a main area for cost reduction.

This study highlighted the fact that the CD process is already changing quite rapidly due to the increasing use of CADD. Although CADD has introduced many efficiencies, many CADD functions are still being performed to look like traditional documentation. By virtue of their easy retrieval and repetition they are not as time consuming as would first appear. These however, still consume much document which results in time required for handling, reviewing, and checking. They also increase the risk of coordination problems. The study calculated that for each extra sheet of drawings, 10-12 hours are required simply for handling and reviewing. One primary goal then, is to reduce the number of sheets. Several proposals specifically dealt with this.

The other main finding is that much of the work included in construction documents does not support the primary function of constructing the building by defining the components, but rather is included to help the designers visualize the project. As more of the identification is done symbolically, it is increasingly difficult to visualize and coordinate the relationship between the components. This study identified alternative time saving methods to accomplish this coordination and visualization separate from the construction documents phase. Much of this work is already accomplished in the design development phase and can be done with quicker, less hardline informal methods. This study also highlighted the need to include the manufacturers and suppliers in this coordination before construction documents, again at less cost to the design team.

VE PROCESS OBSERVATIONS AND CONCLUSIONS

In this limited demonstration study, dramatic results were achieved by using a formal VE process. In the information stage, some of the team members who had not had experience in VE were frustrated since they did not understand where the process was taking them. They also had some difficulty understanding the significance of basic VE concepts. The concept of "worth" is very difficult to understand and to determine for those that have not yet seen how it is applied. Also, the term "worth" means different things to different people. Most lay people think of the term "worth" to mean "value." Perhaps a different, less ambiguous term should be used such as "X-factor." Once the team was in the speculative phase, there was much enthusiasm and much surprise at the number of alternatives possible when the focus is on function and not on the specific component. More VE training is indicated for the VE team members in future sessions.

Additional training and preparation is easily justified, given the high dollar value of savings relative to the cost of the study. In this demonstration session 589 hours ($40,000) of savings were identified relative to the 150 hours ($8,000) of professional time spent on the study. Given that the CD process will be repeated many times in other projects, this return on the investment will be magnified substantially.

One final observation to be made from this study is similar to that made about the CD process itself. Just as CADD and automation have already improved the efficiency of the construction documents, so can additional automation improve the VE process. A computerized database would facilitate cross-referencing of functions for the entire design and construction process to consolidate and/or eliminate unnecessary functions. There are techniques in the industry such as "ConDoc" that increase this cross-referencing, but VE would encourage this to be done on a functional basis, rather than a traditional component definition basis.