ABSTRACT

VALUE ENGINEERING
FOR
THE PRACTICE OF ARCHITECTURE

by
Husam Akoud

The practice of value engineering has become a significant factor in the construction industry during the past five decades. To value engineer a product or an item is to examine carefully its components in relation to their respective performance. Alternatives are generated to enhance functionality and reduce cost.

Techniques and methods have been developed to assist in performing a value engineering study that has a substantial impact on the final product, whether an item in a system or a building component. The different phases of value engineering are the *INFORMATION, SPECULATIVE, ANALYTICAL and PROPOSAL PHASES*. Each phase has its unique techniques which provide a useful tool for the value engineering team in performing a comprehensive study.

Value engineering in architecture represents a radical change from the traditional method of practicing design. Value engineering techniques offer a plateau for better built environments. It helps to scientifically criticize and examine the functionality and performance of different building types, elements and systems in relation to quality versus cost.

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Husam Akoud

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APPROVAL PAGE

VALUE ENGINEERING
FOR
THE PRACTICE OF ARCHITECTURE

Husam Akoud

Dr. David Hawk, Thesis Advisor — Date
Professor of Industrial Management, NJIT

Dr. Peter C.Papademetriou — Date
Graduate Program Director, School of Architecture, NJIT

Michael Mostoller, FAIA — Date
Professor of Architecture, NJIT

BIOGRAPHICAL SKETCH

Author: Husam Akoud

Degree: Master of Architecture

Date: August 1998

Undergraduate and Graduate Education:

- Master of Architecture
  New Jersey Institute of Technology, Newark, NJ 1998

- Bachelor of Architecture
  University of Khartoum, Sudan, 1987

Major: Architecture

To My Wife, Hala,

My Brother, Mohammed,

My Father and Mother,

and My Brothers and Sisters.

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PART I

CHAPTER I

INTRODUCTION

Money has been used throughout history in many forms for the exchange of goods, services or commodities. Its forms of use include stones, ivory, wampum beads, tobacco, furs and dried fish. Money does not, however, rely on its intrinsic commodity value. It is only the implication of representing value that gives money its significance. This provides a basis for manufacturers and suppliers to change quality. It has also allowed for the concept of a one to one relationship between quality and price; common since the industrial revolution. In recent decades, this has helped supply markets with plentiful products at lower prices via mass production. This has provided the current basis for the rethinking of how value relates to quality.

Now, with the development of the information age, the relationship has become more complex. New terminologies and concepts in business drive today's economics and impose a complex set of constraints on architectural practice. Architecture as a collaboration of many different issues of physical environment and economic aspects, faces a difficult existence. The recent demand for better quality buildings at lower prices has become an important factor in most transactions of building design and construction.

However, the current value and quality interrelationship requires a broader understanding of constructional, economic and social value issues, as seen in the *American heritage Dictionary* definition of value:

Value (noun):

1. An amount, as of goods, services, or money, considered to be a fair and suitable equivalent for something else; a fair price or return.
2. Monetary or material worth: *the fluctuating value of gold and silver.*

3. A principle, standard, or quality considered worthwhile or desirable.
4. Mathematics. An assigned or calculated numerical quantity.

Value (verb):

1. To determine or estimate the worth or value of; appraise.2. To rate according to relative estimate of worth or desirability; evaluate.
3. To assign a value to ....

The introduction of the systematic approach of value engineering came from an engineer called, Lawrence D. Miles, who was working for General Electric. L.D. Miles has developed what is known as "*function thinking*" in the year 1947. It was then called Value Analysis until 1953 when he was invited to make a presentation to the US Bureau of Ships and for their purposes it had to be called Value Engineering/Management. The addition of the word management widens the scope of the value analysis, engineering, management technique in developing a decision making model that caters for the various variables affecting the design and construction processes.

According to the *American Heritage Dictionary* the word management is defined as:

1. The act, manner, or practice of managing; handling, supervision, or control.
2. The person or persons who control or direct a business or other enterprise.
3. Skill in managing; executive ability.

The definition offered by the Society of American Value Engineers is:

"Value Engineering is the systematic application of recognized techniques which identify the function of a product or service, establish a monetary value for that function, and provide the necessary function reliably at the lowest overall cost."

Another definition is provided by J. Jerry Kaufman in an article published in Ekistics May 1989, ***" An organized effort directed at analyzing the functions of goods or services to achieve those necessary functions and essential characteristics in the most profitable manner."***

The classical method of value engineering for architects is between nodes of the design process. This method is simple and straightforward but the results are not always optimum. The client reviews the design after each phase and conveys his remarks, which may or may not contain concerns of cost, durability or function. The technical knowhow of architects is important to reflect the strengths and weaknesses of the proposals and suggestions made by the client. Nowadays clients tend to be more sophisticated and demand high quality at the lowest prices possible which compel architects to differently approach the design problem. This means that architects are obliged to take command of some techniques that can help them achieve their clients goals with regard to value and cost.

The value engineering approach in essence is a decision making system which foster the elimination of unnecessary elements or functions from a project without decreasing its functional, qualitative or aesthetics value.

The functional thinking of value engineering with its two folds of quality and cost control can be integrated in the process of architectural design through completion of building process. While architecture is to provide an humane enclosure, value engineering is focused in refining the outcome in its physical context.

However, the process consist of two main elements design and construction. The thesis will focus on the former with its intricate issues and aspects. Creativity in architectural thinking has been aimed at the aesthetics of form and volume not function or cost. This line of thinking is being carried since the Bauhaus started teaching architecture in 1919 in Weimar-Germany. It is dated even back to the Ecole des Beaux-Arts in the 19th century. Integrating value engineering or if we may say “value architecture” in the process of learning and hence the professional practice of architecture would mean more subtle designs and eventually buildings. The significant factor in choosing a building material is its price, then its durability and appearance.

Quality versus cost is the major concern of value engineering which should be as well for architects. Cost has been the synonymous issue in construction industry as the building process and materials choices get more sophisticated. Architects are still dreaming of an ideal client and a utopian environment to practice architecture.

The goal of the thesis is to explore the potentials of value engineering which has been applied to manufacturing process and develop a model for architecture. The thesis will focus on producing a conceptual model for functional thinking in architecture to enable architects to integrate value engineering in their practice. Cost which has been a vital element in building industry can be totally integrated with design through construction. Thinking of buildings as products can open new avenues for reaching the ultimatum of the ideal building, not as a concept but a reality. The thesis will develop a conceptual model for practicing value engineering through the different design phases. Reading will compose the backbone of the thesis which will provide the basics for the interviews and data collection.

PART II

CHAPTER II

DEVELOPMENT of VALUE ENGINEERING APPROACH

The introduction of wheeled wagons was a great step in transportation. The major problem was the unpaved roads that are not suitable for smooth wooden wheeled wagons. By the 1820s the steam locomotive was invented to reach a speed of 14-15 Km/h from the modest speed of 10 Km/h. Special roads has to be constructed to carry heavier loads and withstand the higher speed of the new machine. Railroads were invented with multi-cars to transport passengers as well as goods between different places. Looking for more economical means to transport goods, drove the industrial revolution to invent new methods. The diesel engine was invented and gave a huge boost to the society and the economy. New methods and procedures were invented to speed construction which was closely related to this evolution. Standardization of building components was developed to build economically sound housing schemes for the vast majority of immigrants who came to urban concentrations. A need for testing value to cost became inevitable so as to reduce the cost of products over time. Buildings were no exception. Value analysis emerged as a tedious effort to solve the predicament of cost, quality and price. In testing value against quality in particular products or designs some questions were apt to answer, see Dell'Isola(2):

Does its use contribute value?
Is its cost proportionate to its usefulness?
Does it need all its features?
Is there anything better for the intended use?
Is anyone buying it for less?
Can a usable part be made by lower cost method?
Will another dependable supplier provide it for less?
Do material, reasonable labor, overhead and profit total its cost?
Is it made on proper tooling, considering quantities used?
Can a standard product be found which will be usable?

Through this system of investigation, unnecessary expenditures are avoided, resulting in improved value for design. Value engineering approach is directed towards the analysis of functions, using a creative and organized technique whose objective is to optimize the cost and or performance of a facility, system or design. The primary concern of value engineering is the elimination or modification of anything that adds cost to a design without contributing to its functions.

A value engineering study is the result of the contribution of a professional multi disciplinary effort of a trained team individuals. One of the most important steps prior to the start of the study is establishing a full scale management plan that follow the functional approach for problem solving. The plan should contain a detailed system of documentation of information and feedback to the members of the team.

Statistically, 99% of the cases studied have a margin of unsatisfactory value that needs improvement. Thus a quest for a systematic approach to improve the quality of products while maintaining a relatively low cost is prevalent and inescapable. Value engineering has emerged as a defined technique trying to balance the equation of cost and quality. There are some factors which should be considered as having the greatest impact on costs, such as the groups involved in decision making, owners/agencies, through their requirements and criteria, and designers through their decisions. Another factor which is important is that a small number of elements of a system or facility contain the most costs. As a rule of thumb, 20% of the elements use 80% of the cost. Generally speaking, the electrical and mechanical equipment and installation consue the bulk of the nominated cost of a certain building. Also the spatial design of spaces and their arrangements contribute directly and indirectly to the mechanical and electrical issues both on initial and long run costs. By designing the required spaces to satisfy a certain concept that might impact these two factors i.e. electrical and mechanical. There are some other factors which are beyond the scope of this thesis including but not limited to, site location and topography, availability of building materials etc.

After the allocation of professional expertise, funds and time for value engineering study, a job plan is outlined to render services in a well defined approach. The phases of the value engineering job plan are:

General Phase
Investigation Phase
Information Phase
Function Phase
Creativity Phase
Evaluation Phase
Recommendation Phase

Each of these phases is carried out with the help of established techniques and methods to analyze the facts and information available to reach an optimal result. As a problem solving system, value engineering technique embodies four separate kinds of thinking preceded by a brainstorming stage called "mind tuning". Mind tuning directs all thinking towards a common objective, followed by the development and refinement of activities, which put the results of the thinking process into play. These types contain the information and assumption search, analysis, creative thinking and finally sound judgement. The first step is the collection of data and information. It is important to document each piece of information on a separate sheet with the source and date for further reference. Secondly, the analysis phase. Thirdly is the creativity stage, in which the group tries to introduce new approaches and techniques that is not necessarily related to the specific problem but can remotely benefit it. No criticism is permitted, to encourage the team produce a lot of ideas. The last step is judgement which is the outcome of the study and should written in simple words and understandable terms. This varies in relation to the type of problem and management personnel involved in the study.

"A problem stated in a solvable manner is half solved"

The acquisition of knowledge enables us to articulate any problem and set it in a solvable manner. There are four piers upon which the value engineering study is built. Namely, human relations and teamwork, concentrate on specifics, overcome roadblocks and finally sound judgement.

Human relations play the most significant role in the value engineering study. Without good relations it is almost impossible to do a discernible value engineering study. Because other teammates are the primary source of information it is recommendable good relations should be encouraged to facilitate the smooth flow of information between them.

The second terminology, which is team work, is a keyword in the value engineering practice. The team who is responsible for conducting the study should be homogeneous in the sense that all members should work together for the benefit of the group. The type of boss/employee relation is totally disregarded in order to complete a successful study.

Thirdly, is specifics. Problems are solved when they are fragmented into smaller ones while general comments and broad concepts are significant roadblocks to value engineering study. Here is an example of roadblocks or stoppers:

The injection of generalities.
The absence of meaningful cost.
The acceptance of answers from sources that are not the best.
The lack of the ability to locate industry specialists.

Arthur Mudge has listed some of the common roadblocks(20):

We tried that before.
Our place is different.
It would cost too much.
That is not my job.

It is too radical a change.
We do not have enough time.
There is not enough help.
That will make other equipment obsolete.
Let us make a market research test of it first.
We are too small for it.
It is not practical for operating people.
The men will never buy it.
The union will scream.
We have never done it before.
It is against company policy.
It will run up our overhead.
We do not have the authority.
That is too ivory tower.
Let us get back to reality.
That is not our problem.
Why change? It is still working OK.
The executive committee will never go for it.
What do we do in our competitor's plant?
I do not like the ideas.
We are not ready for that.
It is not in the budget.
You can not teach an old dog new tricks.
It is a good thought, but impractical.
Let us hold it in abeyance.
Let us give it more thought.
Top management will never go for it.
Let us put it in writing.
We will be a laughing stocks.

Not that again.
We would lose money in the long run.
Where would you dig that one up?
We did all right without it.
That is what we can expect from staff.
It has never tried before.
Let us shelve it for the time being.
Let us for a committee.
Has anyone else tried it?
What is the use?
Customers will not like it.
It will be too hard to sell.
I do not see the connection.
It will not work in our industry.
What you are really saying is ....
Maybe that will work in your department, but not mine.
Don't you think we should look into it further before we act.
Let us all sleep on it.
You are right, but ....
You are two years ahead of your time.
We do not have the money, equipment, room or personnel.

The proposed system must locate unsuspected areas responsible for higher costs. An example is provided here to highlight these problems at the beginning of the study:

Management organization

Marketing concepts. (customer functional understanding)

Engineering detail

Manufacturing concept or approach

Manufacturing operation

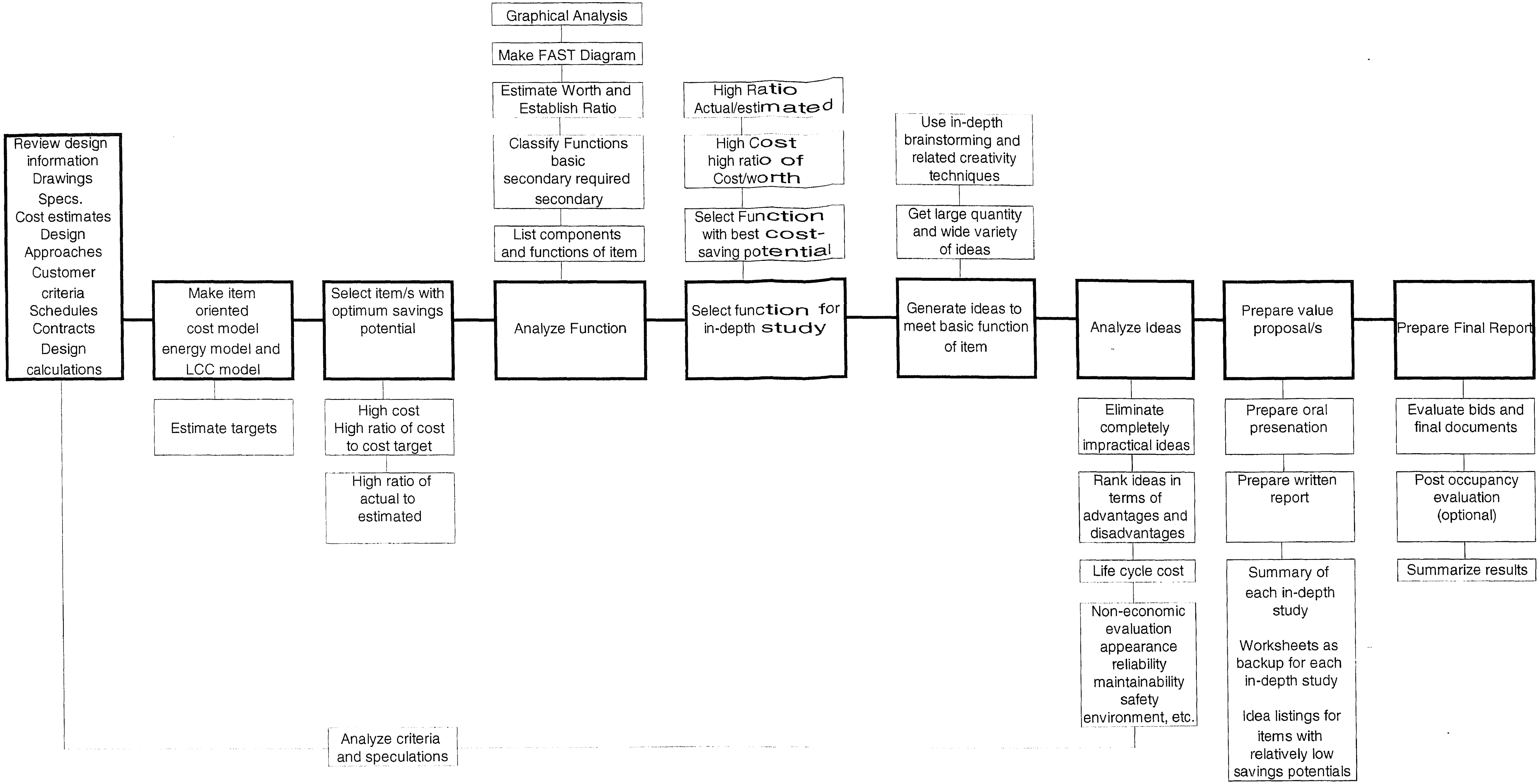
Purchasing or materials procurement work

Finally is the judgement phase. After the accumulation of facts and analyzing them, putting them into focus, judgement should be a routine procedure. Nevertheless, it appears from experience that the fear of failure prohibits the implementation of new ideas and techniques. This is one of the major obstacles in value engineering studies. The team should base judgement on pure facts and results not on emotions or desires of pleasing superiors. The keyword in applying sound decisions is open mindedness. The search of new knowledge and experience should continue throughout the value engineering study. From this we can interpret that the team should work together and coordinate with a good system of communications.

To summarize this part, value engineering study is performed using special techniques and approaches which influence the decision making mechanism and mentality by providing a unique way of looking at problems and hence solutions. It is obvious that no ultimate or perfect answer is reached through the suggested procedures of the value engineering study, nevertheless, a reasonable solution can be sought to create a new approach to a certain problem by carefully scrutinizing it.

1. Exhaustive accumulation of information and identification and improvement of assumptions.
2. Penetrating analysis with what senses of direction does this information provide us? What specific problems will, when solved, bring important cost benefits?
3. Creative mental activity, in which all judgment is temporarily deferred to form the roots of a variety of different solutions to each of the specific problems developed in the preceding analysis.
4. Judgment - type mental activity, in which the results of creative thought are searched for idea roots in order to minimize the disadvantages and maximize the advantages sufficient to meet the need for cost and/or operation improvement. See Dell'Isola(5).

Value is always increased by increasing costs (while, of course, maintaining performance). It is also increased by increasing performance if the customer needs, wants, and is willing to pay for more work. The proposed system must locate those unsuspected areas responsible for higher costs.



THE ORGANIZED APPROACH OF VALUE ENGINEERING / MANAGEENT JOB PLAN
Ecerpts from " Tchniques of Value Analysis and Engineering "
Miles, L. D., NY, McGraw-Hill 1972

CHAPTER III

PHASES OF VALUE ENGINEERING STUDY

INFORMATION PHASE

The first phase in value engineering job plan is the information phase. In this phase a relentless search for information is required, because more information lead to better understanding of the particular problem and hence good solutions. Some techniques have been developed to assist in investigating, recording and analyzing the information accumulation. The three main techniques used in this phase are namely, function analysis, definition of costs and evaluation of worth. Functions have to be defined clearly for each element or design procedure. Questions of how, *what, why, where and when* have to be answered fully and meticulously. The following worksheet is an example for recording information. Fig. 2-2.

As shown on Fig. 2-2 the source of information is stated along with the information provided and the action taken, to secure credit for every person participating in the study. The basic information for each project should be recorded in every sheet i.e. project name, date, drawing and reference numbers. To determine a certain function, the verb-noun technique is used to assist in analyzing the information gathered.

VERB - NOUN APPROACH

The verb-noun approach is one of the techniques that enables the value engineering team to work on a specific function of the design problem. To facilitate a function analysis, a function of any item, component, or design is defined literally by two words; a verb and a noun. The verb answers the question, what does it do? This question focuses attention on the FUNCTION rather than on the particular design. The noun answers the question, what is it? Which focuses on the nature of the element in relation to the whole design or system. A measurable noun together with a verb provides a description of a work function (e.g. transmit load, support

Key Letter	Source	Function	Weight
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
L			
M			
N			

Figure 2-2 A work sheet for documenting information
Excerpts from " Methods in Environmental and Behavioural Research"
Bechtel Robert, R. W. Marans and W. Michaelson.
NY, Van Nostrand Reinhold

Materials, Products

Verbs	Nouns
Absorb	Air
Allow	Compression
Alter	Energy
Amplify	Flow
Change	Heat
Increase	light
Insulate	Oxidation
Prevent	Radiation
Induce	tension
Reduce	Torque
Resist	Weight

Systems, Procedures

Verbs	Nouns
Accept	Adjustment
Acknowledge	Performance
Advice	Requisition
Balance	Data
Compile	Inventory
Edit	Price
Process	Terms
Transform	Customer
Identify	Computer

Figure 2-3 Example of Verb Example of Verbs and Nouns
U.S. General Services Administration (GSA) " Life Cycle Management Model For Project Management of Buildings" Washington, D.C. 1972

roof, store waste). Fig. 2-3 gives an example of two words describing a function. If a pipe supplies water to a building it can be described as "provide service" where service is a non-measurable noun which blocks the thinking of other alternates. If the function is described as "transport water", water is a defined noun and opens the door for more creative ideas. This technique is referred to as two - word abridgement. The advantages of the two - word abridgement can be summarized as follows, as noted by Dell'Isola(5):

- Forces conciseness. If you can not define a function in two words, you do not have enough information or understanding about the problem, or you are trying to define too large a segment of the problem.
- Avoids combining different functions and ensures that only one function is defined at one time.
- Facilitates the task of distinguishing between primary and secondary functions because it helps to identify each function as specifically as possible.
- Aids in achieving the broadest level of disassociation from specific designs or Previous solutions.

There are two types of functions, use functions and esteem functions. The use or work functions are directly related to the utilitarian purpose of the particular design and its use value. The esteem or aesthetics functions are directly related to the desire of the user to acquire an item or a feature in excess of bare utilitarian value.

Basic functions define a performance feature that must be attained from the point of view of the user or client. It resembles the reason for the existence of the item or the need of the user to which he is willing to pay. Certain criteria should be considered in defining a basic function. The difference between basic and secondary functions depends on the point of view of the beholder i.e. it is different from the point of view of the designer, or the manufacturer. A basic function for the designer could be secondary to the user. Thus a clear apprehension of the user needs is significant in the definition of a particular function. For example, a window is designed in an office building to serve the function " view outdoor ". the same window in a warehouse is there to serve the function "ventilate space ".

Some elements in one design are to serve more than one basic function e.g. a space to house people is also to serve for convenient location, which is for both work and sell basic functions.

Basic functions should be defined in the broadest possible terms to provide an opportunity for greater improvement in ideas simulation.

Secondary functions define performance features in an element of design other than those which must be achieved. They primarily express the user's desires rather than needs. The secondary functions give the answer to the question "what else does it do?" e.g. exterior paint function is:

Protect surface "basic function"
Improve appearance "secondary function"

Secondary functions may also exist as a result of a method or procedure being used by the same element. They become secondary to facilitate the accomplishment of the basic function.

FUNCTION RELATIONSHIP

In evaluating functions in a system or design, it is information to work from top down. Functions relationships are described in terms of their affinity to each other in design. The position of the item within the whole design is called its level of indenture. The function is considered basic when it is dependent on the indentured item. On the other hand, the function is secondary when it is independent of the indentured item. Fig. 2-4, 2-5, explains these types of functions. in Fig. 2-4, instead of choosing "ring bell" as a definition of function, the term "make noise" is chosen to give broader concept and allow for creative ideas. At the second level of indenture the two items have basic functions upon which the system is dependent.

Thirdly, only bells perform a basic function. This constant nature of interrelationship between functions can only be realized when a complete understanding of functions is achieved. However, when looking at the overall design problem many secondary indentured items have essential functions in terms of maintenance, operations, safety and environment.

VALUE OF FUNCTION

As described in the introduction value is “a fair …… return.”, when associated with function, some questions would highlight the nature of each function in the broader context of the problem. Dell’Isola has listed some of these questions as follows(2):

What is measure?
Must it be proved?
Should explanation be given?
When do we get into the creative step?
When is a real and final measure established?
How do we get people to place confidence in the measurement?
How do we divide the work so that our associates do not think we are taking their work?
Must this method be known?
Will this method be difficult to use with many products?
How will we motivate men to use the measurement we make?
To whom will we present our results?
Is it of troublesome to the superiors to have new advises for decision making purposes?

ANALYTICAL PHASE

In this phase, which is sometimes called the evaluation and investigation phase, the team examines the alternates generated during the preceding phase and then develops them into lower - cost or energy - saving ideas and lists feasible

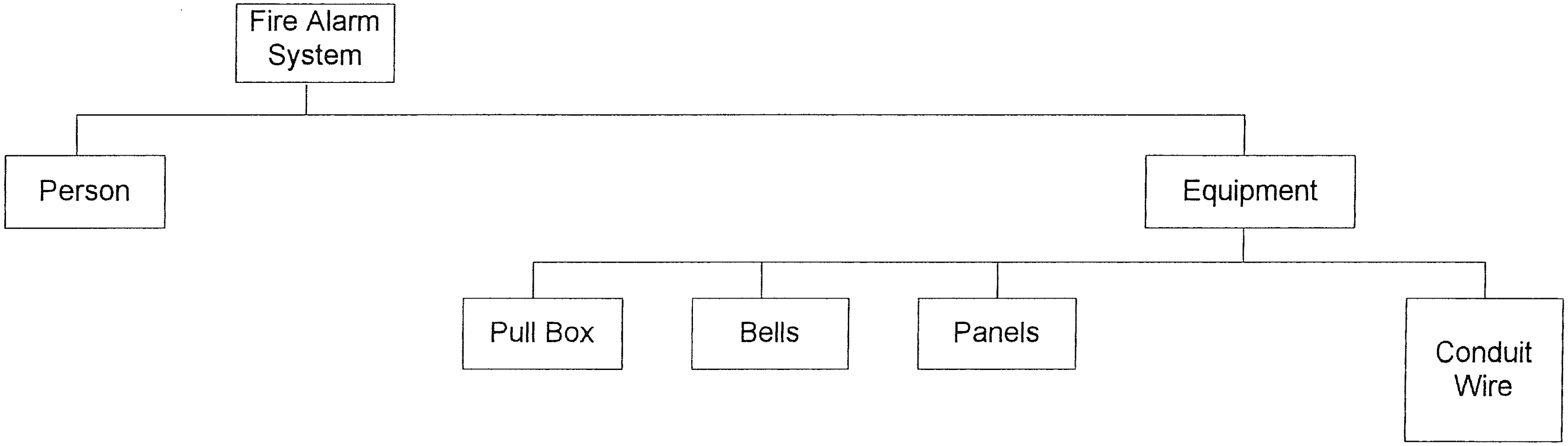


Figure 2-4 Electrical Bell System Model
Excerpts from " Techniques of value Analysis and Engineering "
Miles, L.D., NY, McGraw-Hill 1972

Level of Indenture	Component	Function	Classification B = Basic S = Seconadry
1	Fire alarm system	Make noise	B
		Detect fire	B
		Protect bldg	S
2	Person	Detect fire	B
		Pull lever	S
	Equipment	Make noise	B
		Transfere signals	S
3	Pull boxes	Break circuit	S
	Bells	Make noise	B
	Panels	Provide power	S
		Control circuits	S
	Conduit wire	Transmit signals	S
		Transmit power	S

Figure 2-5 Example of Functional Relationship
Excerpts from "Creative Design Decisions"
S.J. Kirk & K. Speckelmeyer. NY, Van Nostrand Reinhold. 1987

alternates in order of descending savings potential. During this phase ideas must be refined to meet the necessary environmental and operating conditions of the particular situation. Ideas should be listed along with their potential advantages and disadvantages. Advantages might be light weight, reusability, low cost. Disadvantages might be high maintenance cost, excessive construction time, too many pieces. Ideas whose advantages outweigh the disadvantages and indicate the greatest savings, are selected for further evaluation.

In assigning idea ratings a forcing technique is used to differentiate between the various ideas given to the team. That means, if there are ten ideas being evaluated, they should be ranked 1 to 10. The best assigned 1, the poorest assigned 10. By using this forcing technique, all ideas are not assigned equal status thus progress can be made in determining which ideas are considered viable and which are not. The value engineering group must use all available sources of information to determine if the alternate they select is truly less costly, and performs the required function without impairing the essential quality, reliability, or maintainability.

After selection of alternates on a cost basis, other elements, not readily assigned dollar values, are brought into consideration e.g. AESTHETICS, DURABILITY. Such elements that add to the architecture of the specific design and have a greater impact on the total value of that design or procedure. Weighted evaluation is a formally organized process for the selection of optimum solutions in areas involving several criteria. In the process, criterion are assigned different values according to their potential impact on a project. The alternates developed are then evaluated against this criteria. The alternate resulting in the highest score is selected for implementation. During the evaluation process, it is important to discuss and weigh the following areas, see Dell'Isola(2):

Needs vs. Desires
Important vs. Unimportant
Trade - off vs. Non - trade - off

There are two processes, which have been developed, to assess weight evaluation; weighing process and analysis matrix. The weighting process criteria is designed to isolate important criteria and establish their weights or relative importance. Analysis matrix is to list and rank each alternate against each criteria. The rank and weight of each constraint are multiplied and totaled. The alternates are then scored for recommended implementation. While making the comparison, each criteria must meet minimum requirements. If we are comparing aesthetics vs. Improved maintenance and operation, the comparison is not between an alternate having an unsuitable looking facility vs. One having unsatisfactory maintenance and operation, but those having increased aesthetics vs. Improved maintenance and operation over any minimum values required.

There are so many patterns of disciplined thinking for value analysis on services work, which include, see Dell;Isola(5):

Definition of the problem area in which better answers are required.

Fragment the problem into smaller units. Each unit is defined by its own type of parameters, and characterised as to basic and secondary problems.

Determine which problems can be solved concurrently and which must be solved consecutively, by establishing a sequence order.

Define the job plan and introduce the thinking and language of function.

What functions are being performed?

What functions are wanted?

What functions are needed?

What functions could be grouped for better solutions?

What functions should be eliminated?

Develop changes in, different groupings of, and alternative means for, accomplishing the functions.

Associate present costs with each function being accomplished.

Evaluate functions and function groups by meaningful comparisons.

CREATIVITY

"Whatever creativity is, it is in part a solution to a problem."

Brian Aldiss

Creativity is the development of ideas new to the individual, not necessarily new to someone else. Creativity produces alternate designs, methods, systems or processes that will differently perform functions under discussion. Although there are so many techniques developed to assist in the creation of new ideas, but does not guarantee a feasible solution.

The process in concluding the creative approach is sequenced in phases or steps. These phases are to be conducted consequently to reach the best possible solution, not necessarily the ultimate. These steps can be grouped as follows, see Dell;Isola(5):

Orientation: Determining and defining the problem to be solved.

a. Preparation: Secure information and pure facts.
b. Analysis: Evaluate data collected.

Ideation: Production of alternate ideas, new designs, processes or systems that can solve the problem.

a. Incubation: Combining and differentiating data and information and slowing the pace to introduce illumination.
b. Synthesis: Derive conclusions from ideas by bringing them into a complete whole frame.
c. Verification: Evaluate the proposed solution.

On the other hand there are as well some mental blocks which have to be overcome to achieve the ultimate goal of the creativity phase. These mental blocks are classified as habitual, perceptual, cultural and emotional. See Dell'Isola(5).

Habitual:

I. The use of phrases such as "tried and true" despite the fact that better alternates exist.
II. The rejection of alternate solutions which are incompatible with habitual ones.

III. Lack of positive attitude and conformity to custom. Reliance on authority.

Perceptual:

I. Failure to use all available senses of observation and acceptance of the obvious.
II. Inability to visualize remote relationships.
III. Failure to distinguish between cause and effect.

Cultural:

I. Desire to follow common customs and methods.
II. Over - emphasis on competition or on cooperation.
III. The trend of being practical which leads to quick judgements without investigation.
IV. The old belief that lenience in fantasy is a waste of time, energy and power.
V. Dependence on reason and logic.

Emotional:

I. Fear of mistakes and preposterous.
II. Boss/employee ordinary built-in fear and lack of trust between colleagues.
III. Too much enthusiasm for success.
IV. Refusal to detour to reach a goal.
V. Failure to reject mediocre decisions.

Two major creativity approaches, classified under free-association techniques, are brainstorming and the Gordon technique. The brainstorming is a problem solving conference wherein each participant's thinking is stimulated by others in the group. It is a spontaneous production of ideas related to the performance of the required function. The other technique is the Gordon Technique which is similar to brainstorming but only the team leader knows exactly the nature of the problem. He leads the discussion with questions that generate ideas.

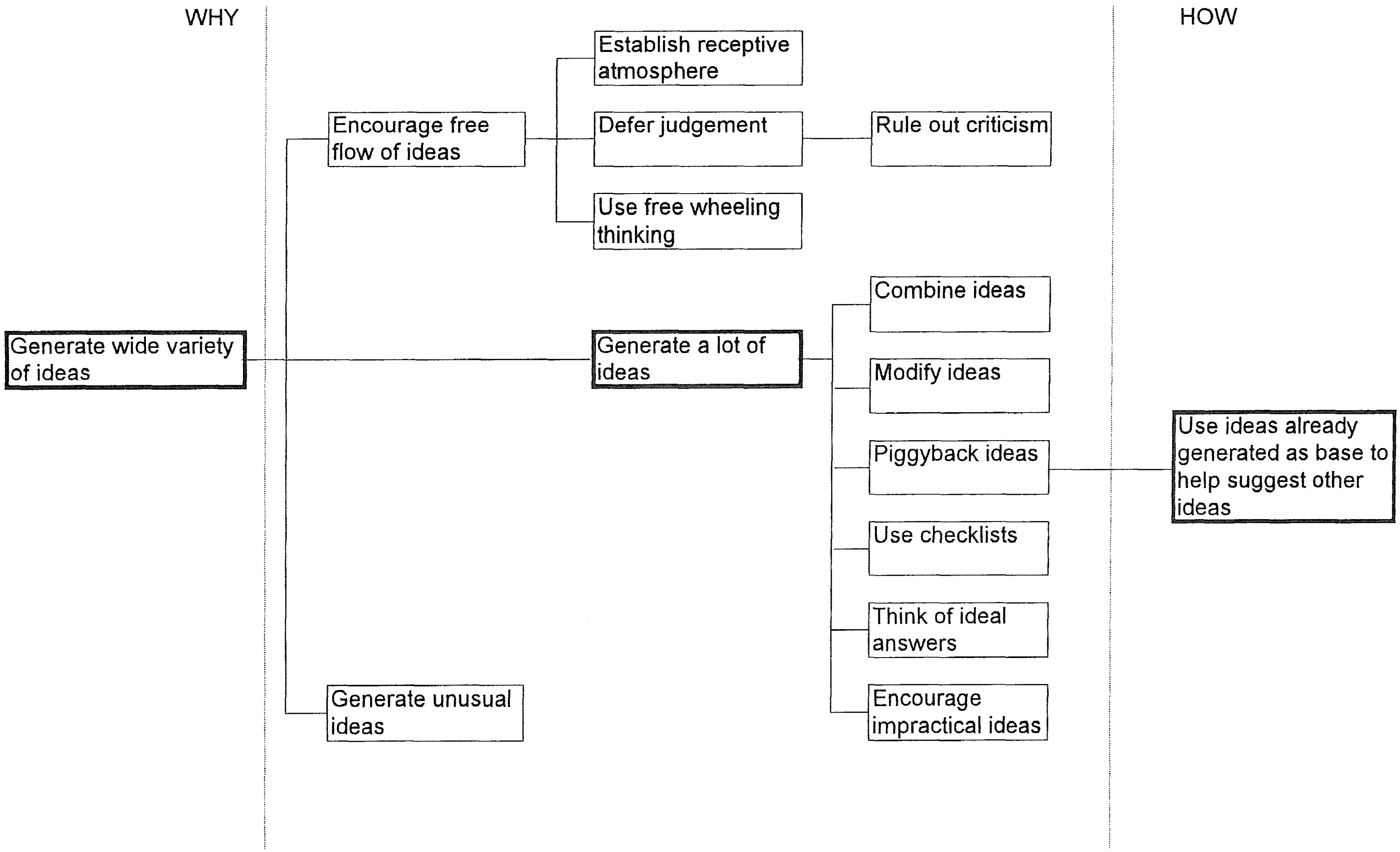


Figure 2-6 'The "WHY-HOW" Logic Diagram for Brainstorming
Excerpts from " Techniques of value Analysis and Engineering "
Miles, L.D., NY, McGraw-Hill 1972

The criteria for selecting the members of the group are that the groups should consist of persons from different disciplines and have varied amounts of experience. No major power relationships. Avoid boss/employee type of relation. Constructive dissatisfaction; improvement oriented ideas; positive thinking, open minded and receptiveness to new ideas. Above all is good communications harmony.

To diagramatically summarize these issues, phases of value analysis/engineering are said to be as follows, see Dell'Isola(2):

INFORMATION

Objectives:

Provide an information base
Select areas for detailed study

Questions:

What is it?
What must it do?
What does it cost?
What is it worth?

Techniques:

Information gathering
Functional analysis
Cost - worth concept
Graphics.
Cost and energy modeling

SPECULATIVE

Objectives:

Generate alternatives for meeting requirements

Questions:

What else will perform the required function?

Techniques:

Creative thinking processes / deferred judgment

ANALYTICAL

Objectives:

Evaluation and selection of best saving alternatives

Question:

What will the alternatives cost?

Will the alternatives meet the required functions?

What proposals have greatest cost savings?

Techniques:

Life cycle costing

Weighted constraints evaluation

Idea ratings

PROPOSAL

Objectives:

Presentation of best alternatives to the decision maker

Question:

How best to present proposals?

Techniques:

Narrative reports

Schematic overlays

Graphics

FINAL REPORT

Objectives:

Define and qualify results

Question:

What was implemented?

Technique:

Bid analysis

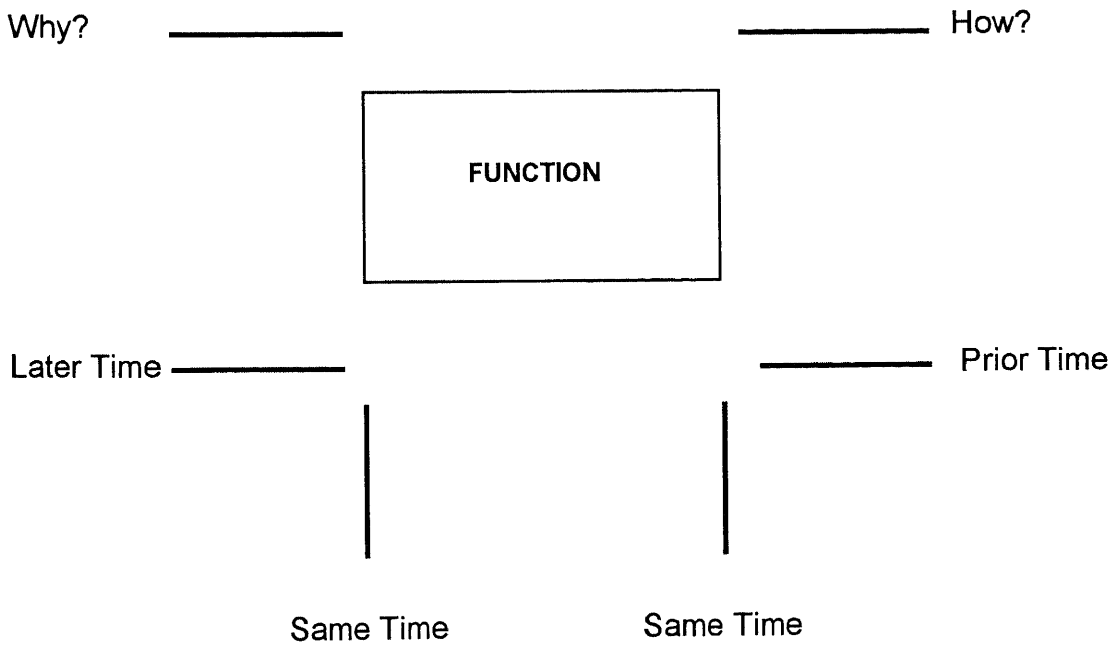
Life cycle cost

Post occupancy evaluation (optional)

FUNCTION ANALYSIS SYSTEM TECHNIQUES (FAST) CONCEPTS:

Use of FAST involves a function block diagram, based on answers to *what? why? how?* The result is a hierarchy of functions showing logical *why/how* relationships, which provides an analysis of functions to achieve an objective or end result.

“It is basically finding an answer to the questions such as, what is the problem? Why is a solution necessary? And how can the solution be accomplished?The FAST technique bridge the gap between high level concepts and the how-to-do-it implementation of those concepts.” See Dell’Isola(5).



Diagrammatic Description of FAST

SUMMARY

SPECULATIVE PHASE

This phase is designed to introduce new ideas to perform the basic function. Therefore, it is necessary to fully understand the problem and, by using problem solving or creative techniques, to generate a number of ideas which introduce lower cost alternatives. Creativity is essential in value engineering studies and procedures. This step is meant to develop a wide range of ways to provide the basic functions and the required secondary functions of the item to which value improvements are being made.

ANALYTICAL PHASE

To list criteria which should be used in making an objective, realistic assessment and comparison of the various ideas, to list roadblocks and undesirable side-effects which may occur if a particular idea is selected as the solution for the value improvement problem.

PROPOSAL PHASE

to find ways of "selling" the solution recommended in the proposal, as well as to help anticipate roadblocks such as objections, stalls and killer phrases which may be used to oppose or disapprove the proposal.

PART III

CHAPTER IV

VALUE ENGINEERING IN ARCHITECTURE
INTRODUCTION

Architecture is probably the oldest of the fine arts. Certainly, it is the most useful and in some respects is a prerequisite for the other arts. Most early texts associate buildings with deities; architecture was not only considered the highest art form, to which other arts were adornments, but some buildings were viewed as representing another, higher realm. In medieval illuminated manuscripts, God was frequently shown armed with compass and mason's square, as architect of the Universe.

The application of value engineering in architectural design process is very complicated because of the intricate nature of the design issues. The subjective characteristics of design is perplex and require a unique technique to measure and weigh them against each other. The conventional method of value engineering a project is by the client at the end of each design phase. It is called the node method, when the client reviews the design and expresses his concerns and changes some requirements. Fig. 3-1 demonstrates this process.

Schematic Design VE Design Development VE Construction Documents

Figure 3-1 Traditional Method for practicing Value Engineering

The systematic approach of value engineering has its constraints when applied to the architectural design process. The numeric equations can measure functions, performance but not aesthetics.

The purpose of decision analysis is to establish a structure that allows the design team to weigh the effectiveness of each alternative against design criteria. The model is intended to produce a conceptual understanding of value engineering and the possibilities of its application in the architectural design process.

The decision analysis model is meant to assist decision makers to objectively define a design problem and systematically sort through the consequences of distinct design solutions. The multi-objective decision analysis evolved from the traditional theory of choice behavior. The theory allows the decision makers to use a range of values to weigh the consequences of their decisions instead of a single measurement scale. The framework for this model is composed of two components that are:

Define design criteria or objective
Generating feasible alternatives

The former element is the key to better decision making policy. These criteria should be defined clearly to decompose the problem of its intricate complexity into a measurable statement. The importance of these objectives is to define the goals and desires of people who will occupy the specific environment.

The latter component is the generation of feasible alternatives that address the design objectives. The alternatives must be able to satisfy all the criteria established by the decision makers in earlier stages of the design process. Space and function diagrams, circulation flow charts and activity analysis are part of feasible alternatives that should be addressed to explicate a set of design criteria. The balance of the requirements implied by the design objectives and the potential of each alternative to fulfill these objectives constitute the decision making model. In general the architectural design process can be phased as:

SCHEMATIC, DESIGN DEVELOPMENT, CONSTRUCTION DOCUMENT

The schematic phase can be preceded by the preparation of the brief. The more detailed the brief the easier the task of performing both design and value engineering. The brief articulates the parameters of the design and sets the objectives and criteria which determines the scope of a particular project or scheme. These objectives are said to be independent of each other and clearly absorbed by both designers and decision makers.

Most of the objectives are subjective in nature and widely variable in meaning. For example, it is very difficult to create a standard system of absolute measurement to conceive a building *image*. R. Bechtel provided an example of approximate accuracy to measure a subjective criteria. Fig. 3-2 shows a design objective scaling worksheet.

It is important to consider carefully the definition of objectives and evaluation of their alternatives. The understanding of the independent nature of these objectives to each other is critical to the progress of the study. Finally is the sound judgment of the different weights given to various objectives.

The conventional approach as described in the introduction is carried at nodes through the process of design, while the proposed technique is to consider the impact of every decision through the design process on the economical and environmental factors of the physical and aesthetical issues. The decision making framework outlined in this chapter is to create a conceptual understanding for architects to take decisions that are based on the various and conflicting aspects of the complex design and building mechanism. The model described later is a preliminary study for evaluating the subjective nature of design.

DEFINING DESIGN OBJECTIVES

As related to the design phases mentioned earlier, defining objectives comes as a first step to enable designers to set parameters to the specific problem. At the beginning of the design process, the objectives are usually general in nature and referred to as program goals. They tend to be more defined and articulate as the design moves into its schematic phase.

Most design objectives can be categorized into economical factors, image-related factors and functional factors. Economic objectives concern either initial construction cost or life cycle costs, while image objectives address the environment and the impact on urban context of the buildings. Image objectives define the degree to which environments enhance the human component of the

1 Low value	Extend amount of employee walking for communication. Circulation system that satisfies simple and direct movement with safety. Mixed circulation for people, vehicles and service. Controlled access to building.
2	Tolerable amount of employee walking for communication Circulation system that satisfies simple, clear and direct movement with safety. Separate circulation for people, vehicles and service. Controlled access to buildings
3	Moderate amount of employee walking for communication. Circulation system that satisfies job function, personal needs ans safety. Separate circulation for people, vehicles and services Controlled access to building
4	Minor amount of employee walking for communication and safety purposes. Circulation system that graetly improve job function and personal needs. Separate circulation for people, vehicles and servise. Restricted access to buildings and parking with separate visitors entry.
5 High value	Minimal amount of employee walking for communication and safety purposes. Circulation system that greatly improve job function and personal needs. Separate circulation for people, vehicles and service. Restricted access to buildings and parking with controlled entry points for employees and visitors.

Figure 3-2 Design Objective Scaling Worksheet.
Excerpts from " Creative Design Decisions "
S.J Kirk & K. stephen. NY, Van Nostrand Reinhold. 1987

design issues of color, texture, comfort and psychological response to buildings. Functional objectives of environment express the physical nature of the different activities with their conflicted aspects of proximity to one another and the potentials of change and expandability. Fig. 3-3 illustrates a list of some design objectives.

SCALING DESIGN OBJECTIVES

As described earlier, using the form in Fig. 3-2 a preliminary scaling of each objective is established. The team leader initiate the discussion by particular questions that prompt the design team to define one issue after the other. For example, " What is the least you would expect in a potential design solution for how the people circulate in this facility?" This question would lead to the definition of the circulation of objective within the design context of that specific building. This process establishes the scaled values e.g. from one to five for each objective. It expresses the characteristics of each objective in a ranked manner, which help the design group to define the weight of that objective. This technique provides a relatively accurate measure for such subjective criterion of the design problem. The technique is repeated for each objective individually. Using the five scalar point helps in visibly defining a public statement of feeling towards a specific design criterion that are shared by the design team. It also points the weaknesses in parts of the design that needed more attention and articulation. The process of defining the scales for design issues involve the participation of the whole design team and allows each member to express his ideas and reasons that concern the design as a whole.

WEIGHING DESIGN OBJECTIVES

Weighing each design objective refines the articulation of the problem and provides clearer image to the forthcoming product. After constructing a scale for each design objective, the team draws attention to relative degrees of importance of these definitions, hence a technique of trade-offs is established. The basic idea is to

Design Objective	Definition
Image	The visual concept of the building and the way in which the building attracts attention to itself. The form of the building and the degree to which it acts as a symbol for the client; whether a company or an individual.
Community	How the building and its site project " a neighbor" identity in terms of safety, security and privacy.
Functional Efficiency	The degree to which the building is able to respond to the work process and flow of people, equipment and materials.
Security	The degree to which the building can segregate sensitive functions from one another and prevent the the entry of people to restricted areas.
Expansion	The ability of the building to grow to meet projected changes in the work process without disturbing existing building functions

Flexibility	The degree to which the building plan can be rearranged to conform to revised work processes and personnel changes.
Technical	How the building performance in terms of mechanical systems, electrical systems etc.
Human Performance	How the building provides a comfortable both psychologically and environmentally.
Energy Conservation	The degree to which the building is able to conserve energy resources through construction, site orientation and solar design.
Life-Cycle Cost	The economic consequences of the building in terms of initial capital investment and long term operating costs.

Figure 3-3 A List of Design Objectives

determine how much of each objective can be taken off to allow for a less valued objective to be considered. In other words how much of the circulation is to be taken off to reach that level decided by decision makers. The completion of this task usually produces a different rank ordering which demonstrates a deeper understanding by the design team of the problem under discussion. Fig. 3-4. It is significant to point out that decision analysis is to render a comprehensive understanding of the problem not to precisely answers complex questions.

To illustrate this procedure an example is provided by Stephen Kirk in *Creative Design Decisions*(4).

Functional efficiency: This objective was judged to be the most important. Set the weight at 1.00

Circulation: A trade-off value at the 2.30 point on the function scale was established. Since this point is approximately a third of the distance up the scale, use a weight of importance of 0.33

Life-Cycle Cost: A trade-off value of 3.75 was chosen by the design team. Since this value is somewhat three quarters of the distance up the function scale use a weight of importance of 0.69

Expansion: A trade-off value at the 3.50 point on the function scale was chosen. This value is slightly less than assigned to life cycle cost goal. Assign a weight of importance of 0.65

Image: A trade-off value of 2.30 was chosen. Assign the same weight as circulation at 0.33

Summary:

00.00
+01.00
+00.33
+00.69
+00.65
+00.33

Grand Total =03.00

No	Name	Description / Definition	Rank Weight
1	Circulation	Movement of workers and materials in a well defined and efficient manner	4
2	Functional Efficiency	Organization and management of activities to allow for maximum work productivity	1
3	Expansion	The ability to grow and change within the building and on the site	5
4	Image	Comfort of the user in physical and psychologic terms. Positive corporate image.	2
5	Life Cycle Cost	Minimization of capital, operating, maintenance, salvage and tax costs.	3
6			
7			
8			
9			
10			

Figure 3-4 Initial Client and User Objectives
Excerpts from ' Creative Design Decisions "
S.J. Kirk & K. Speckelmeyer. NY, Van Nostrand Reinhold. 1987

The new normalized weights of importance of the value statements are:

Function	1.00/3.00	=0.33
Life-cycle cost	0.69/3.00	=0.23
Expansion	0.65/3.00	=0.22
Circulation	0.33/3.00	=0.11
Image	0.33/3.00	=0.11
Total		=1.00

GENERATION OF ALTERNATIVE DESIGNS

As described in part one of this research, a brainstorming session is held imformally to allow design members to produce new ideas and general solution to the problem. Evidently these solutions tend to be more specific and clearly lucid as the design progresses from schematic to development stage. Each solution should satisfy every design objective, at least at the lowest acceptable level on the scalar value system. When an alternative is viewed as desirable by decision makers and does not satisfy the requirements, objectives not met should be revised to accommodate the new alternative. The alternatives follow the progression of the design, from abstract forms and relationships diagrams to more spatially defined environments and well related activities.

An abundant of alternative ideas should be generated to test the extremes of the design problem. When widely divergent opinions are investigated, new approaches to a problem are often revealed. After recording a number of alternative ideas, the team is asked to respond to each one against the previously constructed design objectives. Each idea is scored as advantageous or disadvantageous to each objective to further clarify the rankings and scaling systems already constructed. This technique enables the team to review the alternatives in a creative and critical manner. The discussions are systematically recorded and organized to suggest proposals to the project designer or programmer.

EVALUATION OF ALTERNATIVES

At this stage the decision makers have already generated a set of measurable design objectives and alternatives. Trade-off exercises created relative degrees of importance to the different design objectives. A set of raw measurements have been established for the various design solutions and their acceptability to meet the stated design criteria.

Each member of the team is asked to record his ratings for each design solution. The assessment is collected and compared as illustrated in Fig. 3-5. A discussion meeting is held to review the valued assessments to formulate a uniform idea or line of decision with regard to all possible solutions provided by the design team. An arithmetic average score is introduced to aid the decision makers to establish a comparative analysis of the different approaches to the problem. The weighted average value for the first scheme, with respect to the circulation objective, is determined by the following equation. See Kirk S.(4):

Weight of Importance for Circulation X Average Circulation Score

The Weighted Average is:

$$(0.11x2.05)=(0.33x3.00)+(3.45x0.22)+(0.11x3.40)+(0.23x1.80)$$

$$=0.23+0.99+0.76+0.37+0.41$$

$$=2.76$$

Organizing the data collected from these two steps in the weighted average decision analysis table, the result is shown in Fig.3-6. The decision makers should review and reevaluate the rankings of objectives with respect to the data provided by the design team. Some questions would arise to highlight the weaknesses of each solution and strengthen the potential qualities of a particular solution. Each member of the design team is asked to analyze the suggested alternatives independently. A meeting is then held to allow members to express their ideas and views about each alternative to reach a prevalent consensus.

	Circulation	Function	Expandability	Sensory Environment	Life-Cycle Cost
1	2	2	2	4	2
2	2	3	4	3	1
3	2	3	2	3	1
4	2	3	2	3.5	2
5	2	2	5	4	3
6	3	3.5	4	2.5	2
7	1.5	4.5	4.5	3	2
8	2	3	3	4	2
9	2	3	4	4	2
10	2	3	4	3	1
Average	**2.05**	**3.00**	**3.45**	**3.4**	**1.80**

Figure 3-5 Assessment for ten Hypothetical Solutions
Excerpts from " Methods in Environmental and Behavioral Research "
Bechtel Robert, R.W. Marans and W. Michaelson. NY, Van Nostrand Reinhold

	Circulation	Functional Efficiency	Expansion	Image	Life - Cycle Costs			Alternatives scores Sum of W.Av.
	a	b	c	d	e	f	g	Total
Weight of Importance	0.11	0.33	0.22	0.11	0.23			
Alternative 1	0.23 2.05	0.99 3.00	0.76 3.45	0.37 3.40	0.41 1.80			2.76
Alternative 2	0.26 2.35	1.01 3.05	0.59 2.70	0.30 2.75	0.56 2.45			2.72
Alternative 3	0.40 3.65	1.22 3.70	0.74 3.35	0.45 4.10	0.98 4.25			3.79
Alternative 4	0.41 3.70	1.16 3.50	0.89 4.05	0.50 4.50	0.79 3.45			3.75
Alternative 5	0.32 2.95	0.83 2.50	0.51 2.30	0.31 2.80	0.30 1.30			2.27
Alternative 6	0.32 2.93	0.97 2.95	0.67 3.03	0.34 3.10	0.78 3.40			3.08

Figure 3-6 Weighted Average Decision Analysis
Excerpts from"Creative Design Decisions"
S.J. Kirk & K. Speckelmeyer. NY, Van Nostrand Reinhold. 1987

A consensus should be reached by the decision makers to determine the direction of the design solution in question. They should select a particular alternative that satisfies most of the criteria set before the initiation of the process. The perceived strengths and weaknesses should be further analyzed by the appointed designer to enhance the optimum solution. It is evident by now that one alternative with low ratings can have a great potential of development to satisfy a high percentage of the set criterion. The most significant aspect of decision analysis exercise is to explore in a systematic approach a collection of alternatives and ideas for a particular design problem. The application of the value engineering techniques through this model is to enhance the collaboration of different design specialists in providing articulate solutions that are innovative and realistic in nature to the decision makers.

Decision analysis is intended to provide a framework for establishing design objectives and evaluating design alternatives. It is not meant to find problems rather solving the existing ones in a systematic approach. The decision model may be applicable at any stage of the design process, however, it is preferable to be applied during the early stages of the design. At the beginning of the design decisions are said to be more general and specific answers are not required. Architects and programmers perceive design objectives to be the initial step in design, while decision makers prefer to define them on tangible information sources. it is a uniform framework that thaw different opinions and theories to formulate a direction for design solution and philosophy. Clients are becoming more sophisticated and can participate within the framework of the process to enrich the outcome results. Clients' values of design objectives are to be considered in terms of their visual impact on the environment.

The earliest attempts at resolving design objectives should recognize the relationship between the visual and abstract nature of the environmental settings. This technique of decision analysis defines the attributes for environmental problems a statement for clients systems of values.

CHAPTER V
SUMMARY

"Architecture can be defined in at least four ways, all valid, all interrelated, and none truly satisfactory. It is the art and method of erecting structures; it is a planned entity, the result of a conscious act; it is a body of work; it is a way to build". A good definition was provided by the Roman architect Vitruvius in the 1ST century AD. and was translated from Latin into English during the 17th century by Sir Henry Wotton (1568-1639). Vitruvius said that architecture is a building that incorporated:

UTILITAS = COMMODITIE
FIRMITAS = FIRMNESS
VENUSTAS = DELIGHTE

This definition recognizes that architecture embraces functional, technological, and aesthetic requirements; it must have commoditie (utilitarian qualities), firmness (structural stability and sound construction), and delighte (attractive appearance).

Value engineering is the academic form of cost reduction practice and is a theory that follow a systematic approach to problem solving. The application of value engineering in design is meant to enhance the output of the architectural work. A modification of the value engineering approach is required to assimilate the design process with its complicated issues and subjective objectives.

The value engineering procedure is practiced through five distinctive steps. The orientation or the information phase is the first step in the value engineering study. During this phase the team collects raw and unsorted information which would be used in the analysis of the problem under discussion. The more information gathered the better the result of the value engineering study. This information is then organized and well documented to help the team articulate the design problem later in the study. Arthur Mudge suggests some typical forms to be used for documentation of information. However, the information collected and sorted during this phase is critical to the progress of the study and upon which the outcome of the study is based. It is important to record every piece of information found, which might avail valuable during the course of the study.

The second is the speculative and scrutinizing phase. The information gathered earlier is deciphered and sifted for evaluation. As has been discussed in the previous chapters, some techniques were developed to assist the value engineering team conduct a thorough investigative analysis of the objectives and alternatives for the design problem. After the value engineering team absorbs the problem and define the client's requirements, which might have been changed, the problem is then configured in an understandable language and a preliminary articulation of the design problem is reached. It is important to note that all facts have the same significance and irrelevant objectives are precluded or dismissed by the end of this phase.

The subsequent phase is the analytical phase. A scrupulous analysis is performed using the available information to reach a clear frame-work for the design problem. Areas of high cost and low function weight is highlighted and different alternatives are brought about for further study. Objectives and issues are discussed and analyzed to offer feasible design and comprehensive solutions to the problem under study. The role of the value engineering study is to provide a concise, yet broad number of realistic alternatives to a definite design or performance problem. A high level of creativity thinking is required to generate different options and alternatives. The different techniques described in the previous chapters is meant to help organize the process of value engineering and is part of the many development attempts by value engineers to implement the theory on practice.

A report of feasible and realistic alternatives and measures is expected at the end of each study. Presentation of results of the value engineering study is governed by the type and character of the problem considered. The decision makers influence the presentation techniques and materials used to convey the solutions and recommendations done by the value engineering team.

The following tables show the results of a study reflecting the implementation of value engineering in the United States.

In architecture, where immeasurable factors in design play a significant role, value engineering is attenuated to the technical aspects of the design objectives. Design concepts have many variables that make it difficult to furnish a tangible set of measures. The articulation of the design problem is done through the proposed model in more general terms that can add a definite perspective to the design process. The basic theory of value engineering is in transforming the objectives into numerical values, while architecture concerns the creative aspects of design. It is evident that value engineering output can benefit the architectural design process in defining attributes of a particular design problem and bases the solution development on solid information and analyses.

The model outlined in the previous chapter is a preliminary framework to explore the potentials of implementing value engineering in architecture and hence construction industry. The model provides an outline framework that enables the design team to define, weigh and scale complex design issues and objectives. The decision making model described earlier is comprised of three distinctive parts i.e. a system of well defined design objectives, a set of at least two feasible design solutions, and a mechanism for comparing those solutions to design objectives. The early definition of a design criteria that satisfy both clients and designers is critical to the progress of work and value engineering the study. The intractable issues in the practice of architectural design necessitate the application of value engineering to meticulously study and analyze design objectives and define the parameters of the work in relation to budgeting and performance.

Design objectives fall into three categories i.e. economic; functional and aesthetical factors. Each category has a group of variables that might be changed according to the nature of the design problem. Economic factors are associated with the cost of construction, life cycle cost and post occupancy. Functional factors concerns the performance of the building as an enclosure relative to inhabitants and the surroundings. Aesthetically, the human component of the building in terms of color, texture and space.

The forms shown on the previous chapter can be modified to meet specific design criteria and issues. While the model can be applied to as many variables in design as required to form a comprehensive understanding of the design problem under study. It is advisable to limit the scope of the job plan to the important factors that govern the design problem.

The advantage of using value engineering early in design is that it can help clients as well as designers fully understand the requirements of the given problem and provides a useful technique that differentiate between desires and needs, and weigh the subjective nature of design issues.

CONCLUSIONS

- Value engineering provides a unique approach to design problem solving, which breaks it down into smaller problems, analyze everyone, synthesizes them tegether and offers a final proposal.
- Develops a comprehensive information framework to assist managers make sound decisions.
- Creates a technical approach which explores various alternatives, methods, technologies and procedures for a typical design problem or element.
- Tests the integral functionality of obvious components and their effect on the overall output.
- Articulates the process of problem solving in the practice of architecture.

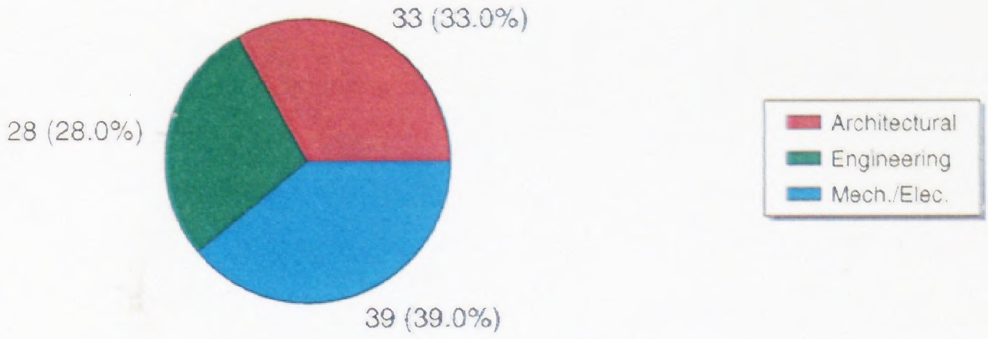
Proposed Savings	**Value**
Number of Studies	55
Total Cost (USD)	28.4
Proposed Savings (USD)	4.8
Averaged Proposed Savings %	32.7

Implemented Savings	**Value**
Number of Studies	41
Total Cost (USD)	28.4
Implemented Savings (USD)	1.8
Average Implemented Savings %	10.7

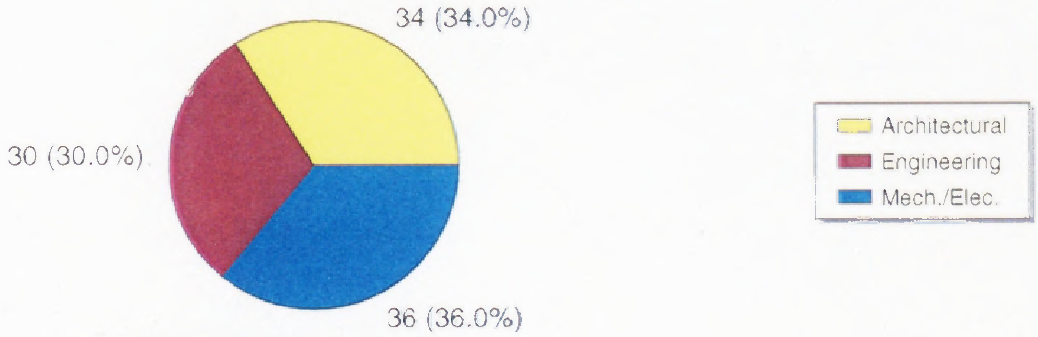
Results By Discipline

	Architectural	**Engineering**	**Mech. / Elec.**
Proposed Savings (% of Total)	33	28	39
Implemented Savings (% of Total)	34	30	36
Implementation Rate	36	31	34

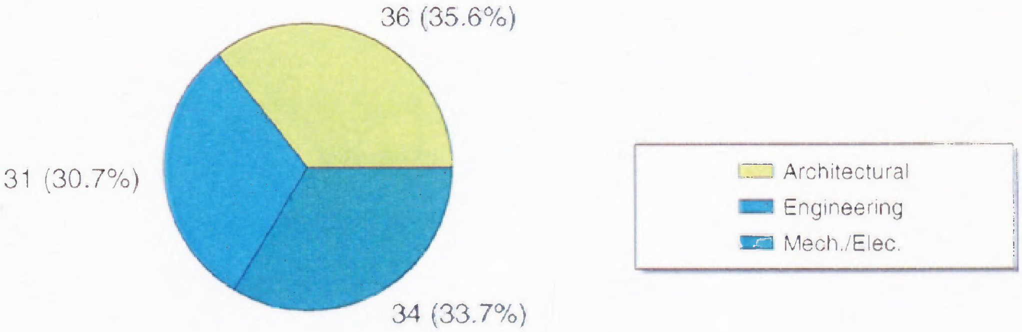
Proposed Savings



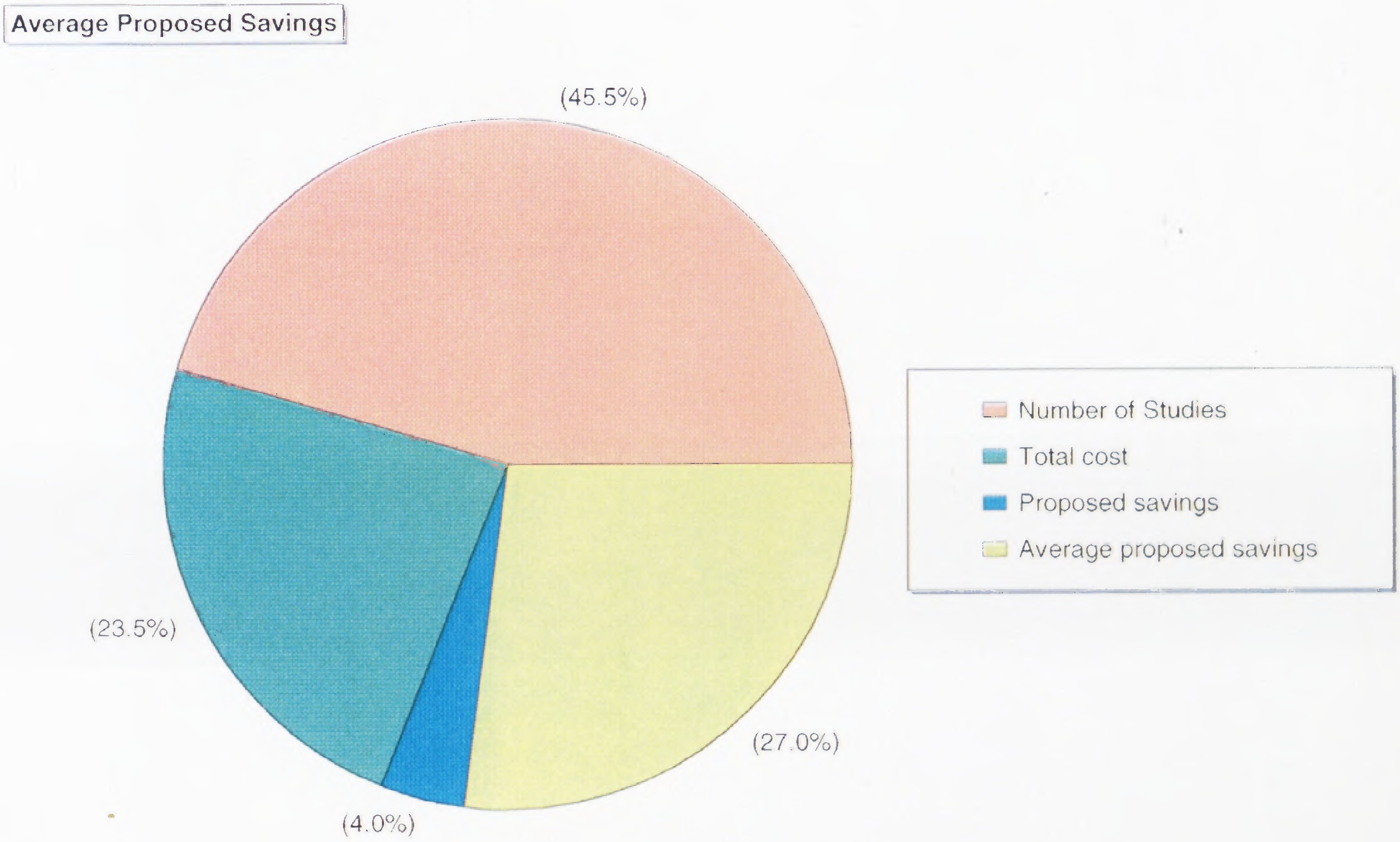
Implemented Savings



Implementation Rate



Results of Value Engineering Studies by Discipline



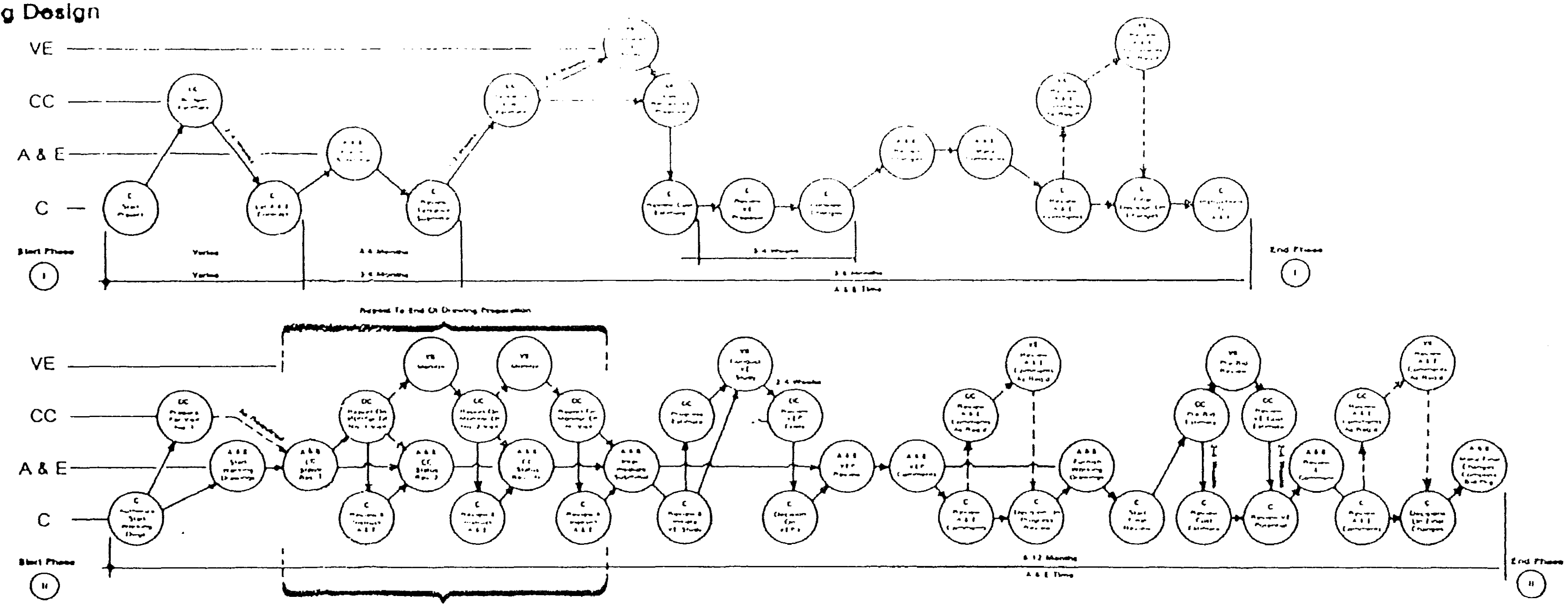
Average Proposed Savings of Value Engineering Studies in the U.S.A.

APPENDIX A

U.S. GENERAL SERVICES ADMINISTRATION

GUIDE LINES OF THE VALUE ENGINEERING SERVICE'S REQUIREMENTS

During Design



VECP Proposal Cycle

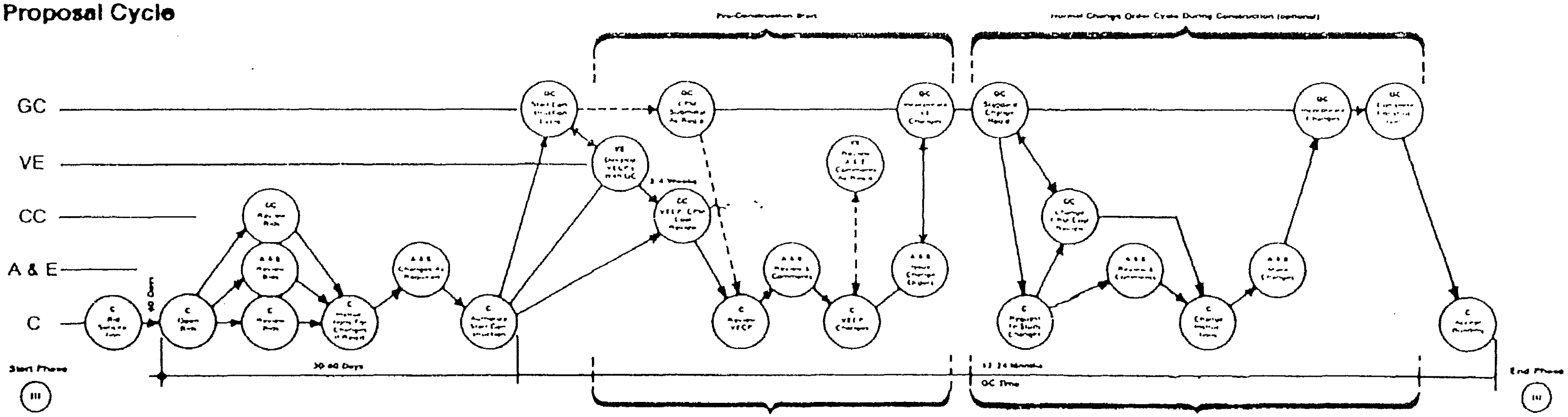


Fig. 6-1. Cost and value monitoring system for major facilities. This system can be varied to fit actual project time. C, government or client; VE, value engineering, in-house or consultant; CC, cost control, in-house or consultant; A&E, architect and engineer; GC, general contractor; VEP, value engineering proposal; VECP, value engineering change proposal.

CHAPTER 2. VALUE SERVICE REQUIREMENTS

PART 1. GENERAL

1. Scope. This chapter establishes the administrative and contractual requirements for obtaining value services under architect-engineer (A-E) and construction manager (CM) contracts awarded by GSA.

2. Applicability.

a. A-E contracts. Requirements for VM services as outlined in this chapter shall be included in GSA contracts with A-E's in connection with the design of buildings, extensions, alterations, repair and improvement projects as set forth below:

(1) Level 1 VM services are required for all projects with estimated construction costs over $200,000.

(2) Level 2 VM services are required for all projects with estimated construction costs over $2,000,000.

(3) Level 3 VM services are required for all projects with estimated construction costs over $5,000,000.

(4) Level 4 VM services are required for all projects with estimated construction costs over $30,000,000.

(5) Special requirements as outlined in this chapter shall be established, rather than level 1, 2, 3, or 4, whenever a construction manager will be utilized on the project.

b. CM contracts. Requirements for VM services outlined in this chapter shall be included in all GSA contracts with construction managers.

3. Contract procedures. VM services shall be included in the initial scope of services required for an A-E or CM contract.

a. Type of contract. VM services shall be negotiated on a firm fixed-price basis for the full scope of services specified in the contract.

b. Phasing. VM services may be divided into separately identifiable phases with performance of each phase, after the first phase, subject to the exercise of an option by the contracting officer. Payments for each phase are made after VM services required by the contract have been approved by the contracting officer.

c. Fee limitations. In accordance with the provisions of Section 304(b) of the Federal Property and Administrative Services Act of 1949 as amended (41 U.S.C. 254(b)), the Administrator of General Services has determined that the portion of an A-E's fee representing payment for VM services may be excluded in determining whether the A-E's fee is within the statutory 6 percent limit, except those items relating directly to the production and delivery of plans, drawings, and specifications.

d. Fee breakdown. Contracting officers shall obtain a breakdown of the fee for VM services that is included in the fixed price contract. The fee breakdown shall correspond to the level of VM services required in each specific contract.

4. Program concepts. GSA's value service requirements are recognized by the major professional societies: American Institute of Architects, National Society of Professional Engineers, and American Consulting Engineers Council. The mutually approved concepts for the program are:

a. GSA requirements do not provide for incentive sharing, with A-E or CM, of savings achieved during design or construction.

b. GSA considers VM a professional service to be provided by the construction manager and architect-engineer.

5. Program objectives. In addition to gaining facilities of better value, GSA recognizes potential benefits in the following areas as a result of providing VM services during design:

a. Time. To some, application of VM causes a disruption of the design process. More often than not, however, early application of VM saves design time by eliminating unnecessary design work, adding to a clarification of the design scope, reducing false starts, and preventing the loss of time that occurs when budgets are exceeded. The more urgent and tight the design schedule becomes, the more these provisions can aid in achieving the desired schedule.

b. Standardization and simplification. It is the inherent nature of a designer to create a special design as a solution to a specific problem. VM ensures that simplification and standardization alternatives are considered in the quest to reduce cost through the analysis of redundant functions.

c. Design deficiencies. When contract requirements are in error, conflict, or are incomplete, they often result in costly changed conditions to the procurement. VM task team reviews performed by personnel other than the original designers have uncovered potential design deficiencies in time to correct them during the design process.

d. Solving problems. VM is one of the best problem solving methodologies available to the contracting officer. Problems with performance, reliability, unforeseen conditions, or quality can be directed for solution to a value task team for study.

e. Special studies and programs. Cost benefit, economic analysis, productivity, work simplification, energy, and environmental studies can all be enhanced by combining them with VM studies and applying VM methodology.

6. Contractor training. It is the responsibility of the Architect-Engineer and Construction Manager to acquire the trained personnel needed to provide the VM services required by contract. However, Architect-Engineer or Construction Manager employees are eligible to participate in VM training courses held for Government employees provided (1) space is available, and (2) the A-E or CM has a current contract with PBS. Such participation is especially encouraged when the VM studies selected for workshop application are taken from the A-E's project.

7. Government processing costs. Costs for the review and administration of A-E and CM participation in VM shall be charged and accounted for in accordance with the HB, Resource Management System, PBS P 3400.10, figure 6-2, where the third character of the work symbol shall be "N".

8 thru 12. Reserved.

d. Level 4 services. VSC requirements for this level shall consist of paragraphs:

100. Scope
101. Definitions
102. Organization and Control
103. Program Manager
104. Cost Models
105. Criteria Review
106. Task Team Studies
107. System Study
108. Component Study
109. Bid-Package Studies
111. Review of VSP's
112. Review of VCP's
113. Government Value Reviews
114. VM Executive Seminar
115. VM Workshop
116. Access to Records
117. Government Furnished Material
118. Fee for VM Services
119. Final Report

e. Special VM services. These requirements for A-E's, in conjunction with CM VM service, shall consist of paragraphs only:

100. Scope
101. Definitions
102. Organization and Control
105. Criteria Review
110. Coordination with Construction Managers
111. Review of VSP's
112. Review of VCP's
113. Government Value Reviews
116. Access to Records
117. Government Furnished Material
118. Fee for VM Services

f. CM VM services. VSC requirements for these services shall consist of:

(1) For level 3, paragraphs:

100. Scope
101. Definitions
102. Organization and Control
104. Cost Models
105. Criteria Review
106. Task Team Review
107. System Study
109. Bid-Package Studies
112. Review of VCP's
113. Government Value Reviews
115. VM Workshop
116. Access to Records
117. Government Furnished Material
118. Fee for VM Services
119. Final Report

(2) For level 4, paragraphs:

100. Scope
101. Definitions
102. Organization and Control
103. Program Manager
104. Cost Models
105. Criteria Review
106. Task Team Studies
107. System Study
109. Bid-Package Studies
112. Review of VCP's
113. Government Value Reviews
114. VM Executive Seminar
115. VM Workshop
116. Access to Records
117. Government Furnished Material
118. Fee for VM Services
119. Final Report

PART 2. SCOPE OF SERVICES

13. Contract clauses. This part illustrates the standard clauses for VM services to be selected as shown below and included by reference to this part of the VM handbook in the applicable contract. Paragraph numbers used below refer to those illustrated in figure 2-13 which, when grouped as specified, formulate a value service clause (VSC) for the procurement.

a. Level 1 services. VSC requirements for this level shall consist of paragraphs:

100. Scope
101. Definitions
104. Cost Models
111. Review of VSP's
112. Review of VCP's
113. Government Value Reviews
117. Government Furnished Material
118. Fee for VM Services

b. Level 2 services. VSC requirements for this level shall consist of paragraphs:

100. Scope
101. Definitions
102. Organization & Control
104. Cost Models
105. Criteria Review
106. Task Team Studies
107. System Study
108. Component Study
111. Review of VSP's
112. Review of VCP's
113. Government Value Reviews
114. VM Executive Seminar
116. Access to Records
117. Government Furnished Material
118. Fee for VM Services
119. Final Report

c. Level 3 services. VSC requirements for this level shall consist of paragraphs:

100. Scope
101. Definitions
102. Organization and Control
104. Cost Models
105. Criteria Review
106. Task Team Studies
107. System Study
108. Component Study
109. Bid-Package Studies
111. Review of VSP's
112. Review of VCP's
113. Government Value Reviews
115. VM Workshop
116. Access to Records
117. Government Furnished Material
118. Fee for VM Services
119. Final Report

14. Guidance to contracting officers. Several of the contract paragraphs require contracting officer decisions to fit local conditions and the particular project in question. The Central Office Director, Value Management, is available to provide specific guidance upon request. The following general guidance regarding each of the contract paragraphs is as follows:

a. Paragraph 102. Design schedules shall include provisions for performing value services and time to implement expected results. A tight design schedule and an urgent need for design completion should not cause requirements to be deleted from the contract. Such situations intensify the need for increased value services occurring in concert with design services. Should the value study reveal a warranted change or recommend a significant cost savings action that would cause slippage in the design schedule, the contracting officer should give favorable consideration to authorizing a time extension, if necessary. The added cost of construction (caused by inflation) due to design slippage and the cost of delay in building occupancy should be considered in determining net cost savings resulting from a value study that requires redesign.

b. Paragraph 104. The cost model provided by GSA Form 3287, Cost Worth Model, represents the distribution of anticipated in-place systems costs for a new facility. For repair and alteration projects, costs should be allocated only to the systems effected. At the concept stage of a project, costs should be presented in parametric form as well as on a gross square foot (GSF) basis. It is preferred that parameter quantities be developed by the original designers for pricing by estimators. A current cost model is required before commencing a workshop.

c. Paragraph 105. It is intended that the design team developing the design concepts perform the criteria review. The designer should be encouraged to question, study, or recommend changes to Government-imposed restrictions whether they be performance criteria, scope requirements, standard prescriptive specifications or special instructions, either imposed directly by the contracting officer or resulting from informal contacts with the client or the PBS staff.

d. Paragraph 106.

(1) The objective of the task team study is to perform a design review to generate suggestions for value improvement of the design. Depending on the scope of the design and the time constraints for completing it, value studies can vary from a one-person effort to team efforts. The maximum size for an efficient value team is five persons supported on a part-time basis by other elements of the design organization.

Before the workshop schedule is approved, care should be taken to know what is to be studied and that the information phase of the VM Job Plan has been completed. Also, contracting officers should anticipate that the workshop will produce recommended design changes and should be ready to process them accordingly.

h. Paragraph 114.

(1) In negotiating a fee, there may be included the costs (salaries) of A-E personnel attending executive seminars or workshops, who will apply the training in performing the design services; the fee may not include the A-E's costs (salaries) of personnel attending executive seminars or workshops who will perform the task team studies.

(2) The A-E will be compensated for implementing changes resulting from value studies when they affect completed and approved design work to date. The entitlement and the amount of compensation shall be determined by the contracting officer before the A-E is authorized to proceed with any changes. Such compensation will be limited to the additional costs of redesign. Value management changes intended to bring the project, as designed by the A-E, back within the budget shall be accomplished by the A-E without additional compensation.

(2) Task team reviews are to be performed by individuals not responsible for the original design. This is intended to prevent extensive interruption of the design process as well as provide a less prejudicial value review. At least 60 percent of the task team should be workshop trained. At Level 4 service, all members of the task team should have completed an acceptable VM workshop.

e. Paragraph 111.

(1) The A-E has the responsibility to accept or reject all the proposed changes created by his employees, submitted by the construction manager, or suggested by the Government, unless otherwise directed by the contracting officer. In so doing, the designer remains fully responsible for the adequacy of his design and his obligation to meet cost or price and schedule requirements of the contract.

(2) Prior to implementing changes that affect completed and approved design work to date, GSA criteria, or other direction, the A-E shall have negotiated the fee for the added work and received contracting officer approval. A-E's are expected to implement VM changes at no additional compensation during the design process when it is feasible to do so, or as determined by the contracting officer to bring the project back within the budget.

f. Paragraph 113. Contracting officers should be aware that they can at any time request internal Government value review of the design to control cost or to solve a problem. Contracting officers may also take advantage of these VM services by directing that certain ideas be studied during the workshop or task team effort.

g. Paragraph 114 and 115.

(1) The location of the seminar or workshop should be in the city where the project is to be constructed. The contracting officer may change this requirement to minimize travel expenses.

(2) In Level 4 service, where both an executive seminar and workshop are required, the executive seminar should be conducted after completion of the criteria review, concept submittal, and cost model preparation. The time should be used partially as a planning session for future task team studies and selection of study areas for the workshop after completion of the submittal of tentative design requirements.

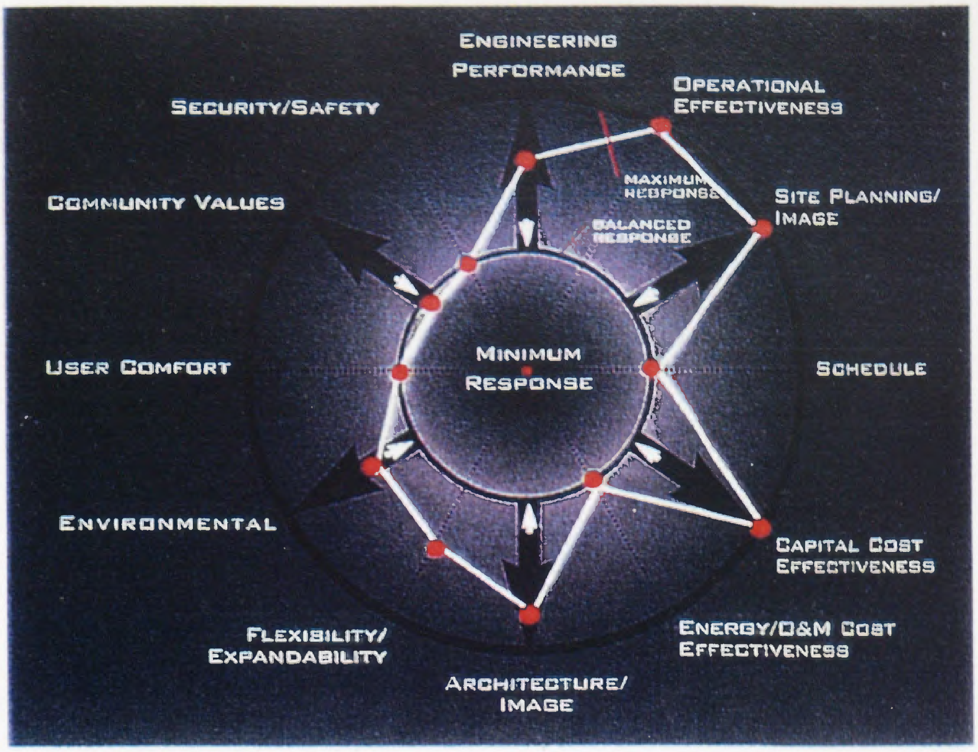
(3) The workshop is 40 hours in length and should be carried through to completion on a scheduled basis in at least one month's time. The workshop should involve employees working on the project design, representation from all of the design consultants, as well as the VM task team. Effective value management requires use of the best talent, those who cannot be spared, so as to take advantage of this opportunity.

APPENDIX B

LABORATORIES OF THE FACULTY OF CIVIL ENGINEERING AT THE UNIVERSITY OF CINCINNATI

Surviving Value Engineering

Analyzing cost-cutting processes can maintain and even improve a design.



ABOVE RIGHT: Smith, Hinchman & Grylls' diagram explains value engineering priorities for its research building at the University of Cincinnati. Higher priorities include building image, site planning, and cost.

Value engineering makes architects see red. Who can blame them? At its best, this management tool opens design to the scrutiny of outsiders who suggest ways of increasing the project's value while saving money. At its worst, value engineering is misapplied to bald cost cutting that has nothing at all to do with value and offers every risk of damaging a design.

But value engineering has become a fact of life in the U.S. construction industry during the cost-conscious 1990s. It is prevalent in major government projects, for which value engineering is now required, and in complex industrial, healthcare, and transportation facilities, for which it is almost routine. Understanding how the process is intended to work and how it can improve a project can give an architect the advantage when confronted with a value engineering study.

Phased analysis

Value engineering is a structured method of analyzing and fine-tuning a project to satisfy the owner's functional requirements at the lowest cost. A true value engineering effort results in a project with the greatest possible long-term value, while considering life cycle costs and the integrity of the original design, explains Ginger Willingham, vice president of Dallas-based value engineering consultant VEI and president-elect of the Society of American Value Engineers (SAVE). "Architects think a value engineer is someone who looks over their shoulder and sees what they did wrong. That's not it at all," asserts Willingham. "Value engineering looks at a project from a functional viewpoint and at the alternatives available to meet that function."

Although value engineering is sometimes undertaken by construction managers or contractors, significant value engineering studies, especially for government projects, are usually conducted by an outside team of professionals led by a value specialist who has been trained, tested, and certified by Northbrook, Illinois-based SAVE. Value engineering teams may include as few as five members—an architect, several engineers, and a contractor may be sufficient for a small job—while larger, more complex facilities such as hospitals or industrial buildings may require a team of 25 or more specialists.

The value engineering process established by SAVE, which can last from three to five days, consists of several phases that must be followed in order. Team members begin by gathering information about the project scope and solutions from architects, owners, and others and analyzing the program's required functions. Then the group holds a brainstorming session to come up with alternative ways of achieving the functions. Brian McGauley, a project manager of Dallas-based Aguirre Associates who frequently serves as a value engineering team member for other architects' projects, says all ideas are welcome at this point. "We put a bowl on the table, and anyone who says, 'No,' or 'It can't be done' has to throw in a quarter," he explains.

move the library to the south, focusing attention inward on the campus to create new quadrants, explains architect Neil Astle. On how he felt about the changes, Astle laughs: "You have to be flexible."

Although the practice of value engineering may be used with any type of contract, the process today is finding a natural place within partnering arrangements, under which the owner, architect, and contractor work together from the start of design, stressing open communication (ARCHITECTURE, October 1993, pages 111-113.)

Lawrence Shaw, who is vice president of Melbourne, Florida-based BRPH Architects & Engineers, a firm that designs technical buildings for the National Aeronautics and Space Administration and other industrial clients under partnering agreements, notes that virtually every one of his projects undergoes value engineering to make sure the right mechanical, electrical, and architectural systems are selected. "It's not adversarial at all. We welcome the input that an outside firm might have looking at our work," he says. Changes were made to skylights, finish systems, and mechanical systems for a BRPH-designed terminal at Florida's Melbourne Regional Airport, for instance, at the suggestion of a value engineering team. "The result was a more economical project that looked just as good or better," Shaw recalls.

Essential elements for success

When the design architect is encouraged and permitted to make a strong contribution to the value engineering process, and if the study is undertaken in an honest and direct manner, then value engineering can introduce a fresh perspective to a design problem. Those familiar with the process warn, however, that the architect should keep in mind several key points to avoid disappointment and potentially damaging consequences.

Critical design issues and decisions should be made known to the value engineering team at the outset. The value engineering team is more likely to respect the architect's design if members understand what the architect believes to be important, points out Eugene Kohn, a principal of New York City-based Kohn Pedersen Fox who is currently working as a value consultant to the Port Authority of New York and New Jersey. "There must be some concept so strong and so valued that you feel is the guts or essence of the design, perhaps to do with space or light," notes Kohn, "that you must explain carefully and fight hard for."

The owner should not be misled by misguided or unsafe value engineering suggestions. Any changes to the design accepted by the architect become the responsibility of the architect, not the value engineer, after the project is built, warns William A. Stimson, a principal of the Orlando office of Hansen Lind Meyer. "If a building that I designed falls down, it would have the same ramifications as for a doctor whose patient died on the operating table," Stimson adds.

The owner should be encouraged to start the value engineering process early, and the team should study issues appropriate to the level of design. The process can be used to question the owner's programmatic or siting choices, if appropriate.

The owner should be alerted to hire a value engineering team whose professional qualifications are above reproach and whose members are respected by the architectural community. "If you get a good team, it diffuses a lot of misconceptions," explains Hanscomb's Dell'Isola. The owner should also be sensitive to issues of competition: Hiring the architect's immediate competitors to review his or her design should be avoided.

The architect should educate the client about what makes good architecture. If the owner wants to use the value engineering study to reduce quality and cut costs, then the architect should explain long-term maintenance and quality issues, advises Robert E. Gray, an architect and capital manager of the New York State Department of Health's Institutional Management Group. "The architect might respond, 'Yes, you can build a cheaper building, but that's not our understanding of your needs,'" says Gray.

Above all, architects should make every effort to remain open-minded and flexible during the value engineering process. "Sometimes you have to say, 'This is just not acceptable; we just can't do it,' " adds Gray. "But at the same time the architect has a clear obligation to accept good ideas. There is no question that some good ideas come out of value engineering."—*Virginia Kent Dorris*

Value engineering can become part of a project contract. For more information, architects should consider attending the AIA-sponsored symposium titled "Cost, Time, & Risk: Evaluating Project Delivery in the Face of Change," March 25-26, in Austin, Texas. Discussions and exercises will enable participants to compare and develop contracting strategies for various types of projects. Contact the AIA at (202) 626-7535 for details, including speakers, topics, and educational credits.

Curran-Fromhold
Correctional Facility
Philadelphia, Pennsylvania
DMJM Architects

An ongoing value engineering effort, led by a construction manager, will ensure the high quality of a 2,000-bed prison and save costs equal to the fees spent for design and construction management combined.

Two value analysis charettes were held early in the design of the Curran-Fromhold Correctional Facility, an intake facility for a variety of inmates. The first occurred during conceptual design and the second took place at the end of schematic design, according to Gregory Offner, senior project manager of the Philadelphia office of Morse Diesel International, construction manager.

"Our philosophy is that value engineering takes place before the architect puts the ink to paper, because if you have drawn it, you've spent money," Offner explains.

SITE MODEL: 2,000-bed prison.

BEFORE STUDY: Laurel Hall (top).

AFTER STUDY: Laurel Hall razed.

The team then evaluates the ideas and selects the strongest suggestions. Those ideas are incorporated into a written value engineering proposal, presented to the owner and architect by the team. The owner, working with the architect and other consultants, subsequently determines which suggestions to adopt and which to ignore.

Painful realities

Value analysis—the methodology that became today's practice of value engineering—was developed in the early 1950s by Lawrence D. Miles, an analyst at General Electric. Miles' procedures were picked up by the U.S. Navy's Bureau of Ships and have since been applied to construction by federal agencies, including the Department of Defense, the Environmental Protection Agency, and the General Services Administration (GSA). Value engineering is currently mandated on federal projects worth $1 million or more, according to the final revision of *U.S. Office of Management and Budget Circular No. A-131*, published in June 1993. That document "requires federal departments and agencies to use value engineering as a management tool, where appropriate, to reduce program and acquisition costs."

Although the idea behind value engineering is difficult to argue against—getting the best building for the best price—its reality can be painful, especially if the term is applied too loosely. One architect remembers a job on which a contractor picked up a set of plans designed by his firm for a government project and claimed that value engineering could cut the cost substantially. When the architect would not approve the changes that had been proposed, the contractor took over the job and was awarded half the projected savings by the government. Shortly after project completion, the building developed structural problems and the contractor filed for bankruptcy.

Even in less dramatic circumstances, the value engineering process can have unwelcome consequences for the architect. John Laping, principal of West Amherst, New York-based Kideney Architects, says there is a tendency for value engineering to "cut, cut, cut until there isn't much architecture left." In recent plans for a one-story nursing home, for example, Laping included bay windows as an amenity in tenant rooms to increase surface area without adding square footage. The windows were removed following a value engineering study aimed at cutting costs and were later listed as a bid alternate.

Indeed, until recently, the success of most value engineering studies was measured in terms of money saved rather than in terms of value achieved, which is less easily calculated. When success is measured by return on investment—$10 saved for every dollar spent on value engineering, for example—even a conscientious value engineer can be driven to suggest changes that detract from the project's quality, according to Michael Dell'Isola, a certified value engineer and vice president in the Alexandria, Virginia, office of Hanscomb Associates, a construction management firm. "Good practitioners try to avoid it, but if you are expected to save money, you have to save it," Dell'Isola explains.

Value over money

To shift the emphasis from savings to quality and value, some practitioners and owners are beginning to measure the success of a value engineering study by the number of suggestions accepted, rather than by the amount of money saved. The GSA, for one, has recently rewritten its value engineering guidebook to stress value over money. Walter Wappaus, general engineer with GSA's office of design and construction, explains that the agency will no longer use value engineering as a tool to pull over-budget designs out of financial trouble and compromise the quality and scope of the projects. At GSA, saving money is no longer the goal of every study. "We feel that the projects that do produce savings will pay for the [overall] value engineering program," Wappaus maintains.

In shifting value engineering's emphasis, GSA and others, including Utah's Division of Facilities Construction and Management, are also shifting the typical value engineering timetable. In the past, studies strictly aimed at slashing costs were started after design was finished and the bids came in high, a process frowned upon because of its limited usefulness. More often, value engineering studies were undertaken when the design was 35 percent completed. Now, however, value engineering is becoming more common during schematic design, when major conceptual changes can be made more easily and the owner can alter initial assumptions.

Such was the case with the Salt Lake City Community College Library, designed by Salt Lake City-based Astle/Ericson & Associates. A value engineering study undertaken during schematic design called into question the siting of the building, dictated by a 20-year-old campus master plan. As a result, the architect and the state jointly agreed to reorient and

Science Research Building
University of Cincinnati
Michael Graves, Architect
Smith, Hinchman & Grylls
KZF Associates

Value engineering is responsible for keeping the 95,000-square-foot, Science and Engineering Research Building on budget without detracting from its bold design. The two-part value engineering effort succeeded because it employed a "force field analysis" at the conclusion of the project's schematic design phase in March 1991, explains architect Stephen J. Kirk, vice president and director of facility economics for Smith, Hinchman & Grylls Associates, the firm that led the value engineering process and also provided planning and lab consulting services to the university project.

The analysis required each participant—owner, architect, engineer, user group member, facility manager, and constructor—to write

SITE PLAN: Circulation a top priority.

BRIDGE: Link to engineering building.

EAST ELEVATION: Contains main entrance.

down the best and worst features of the project. The team then reviewed the list and sought to enhance the strongest aspects of the design and to correct the weakest. "Unless you ask people about the best features, they do not want to talk about the bad ones," explains Kirk. "If we fixed the bad features, we would be helping to create a better project."

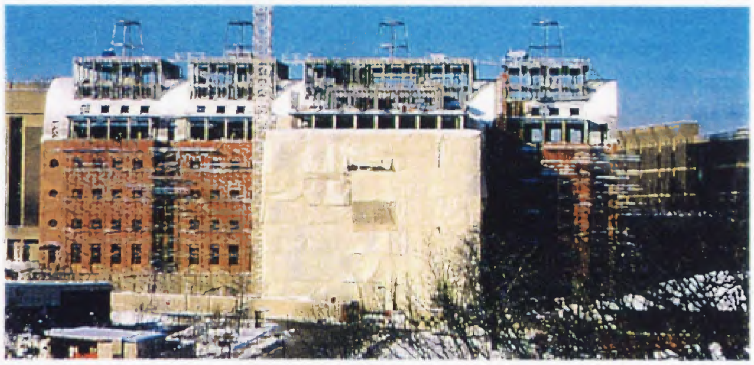
Ensuring that the building functions optimally on its site, which is expected to become a major circulation route for both students and those working in the labs, was a top priority of the value engineering effort. Some other priorities that were identified by the team included maximizing the research building's operational effectiveness while minimizing initial capital costs and maintaining a strong architectural image for the structure, according to Kirk.

The building's distinctive copper roof, although an expensive item, was cited by many participants as an essential design feature so it was not changed during the value engineering process. Instead, attention was focused on finding a better use for the six-story building's attic. The value engineering team developed a plan to shift mechanical equipment from the basement to the attic, which simplified construction of footings as well as foundations.

Estimates of early plans revealed the roughly $30 million project was $7 million over budget before the first study. A two-day value engineering workshop generated 145 ideas, 40 of which were developed to save $6.87 million. Suggestions accepted by the owner included bracing the structure without moment frames, saving about $106,000, and adding 1,000 square feet of cleanroom laboratory space, which added $537,000 in expenses.

A second, three-day value engineering workshop was held in August during the design development phase. Suggestions made at that stage of design, including rerouting laboratory piping and simplifying stone cladding on upper floors of the research building, were less dramatic in terms of cutting project costs, and more focused on quality enhancement and life cycle cost analysis. About $500,000 was saved as a result of the many ideas generated during the second workshop.

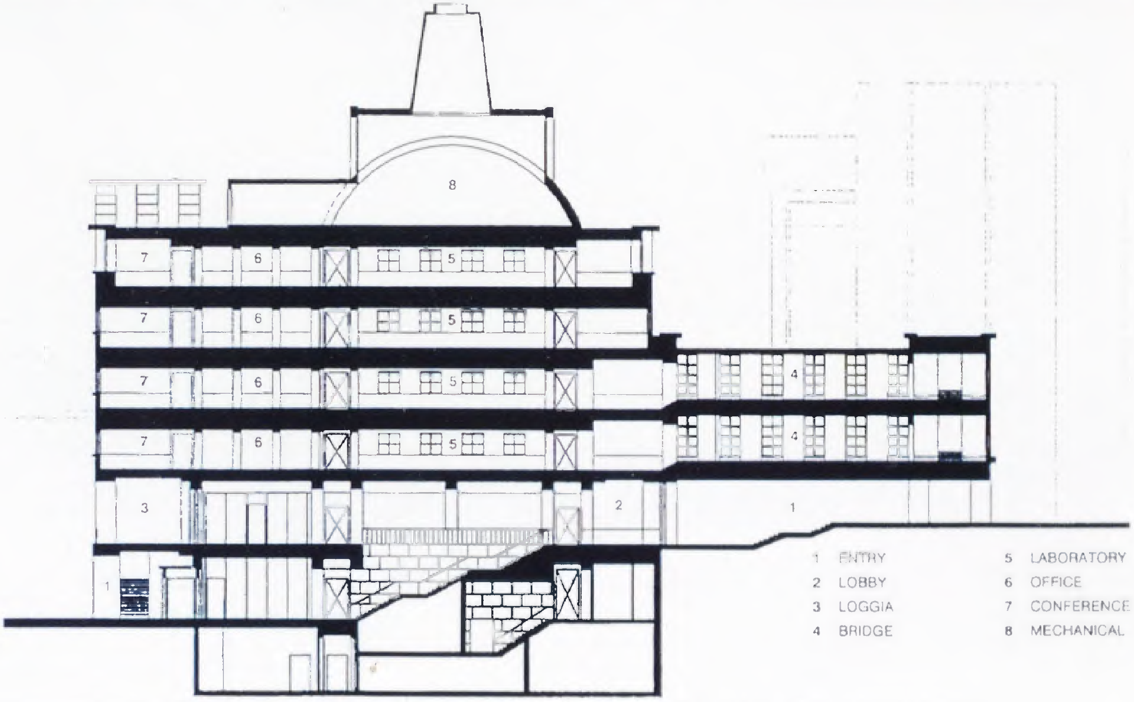
Although the practice of value engineering has become increasingly common on institutional and commercial buildings designed by Michael Graves, the analysis of the University of Cincinnati research building, now under construction, was "more elaborate that anything I've been involved in before," recalls Tom Rowe, senior associate. Changes suggested did not alter the parti, and the process ran smoothly, Rowe adds. "Clients take what we say about design a little bit more seriously," explains Rowe. "At the same time, we have to talk to them from the beginning and show them that we are not spending their money foolishly."



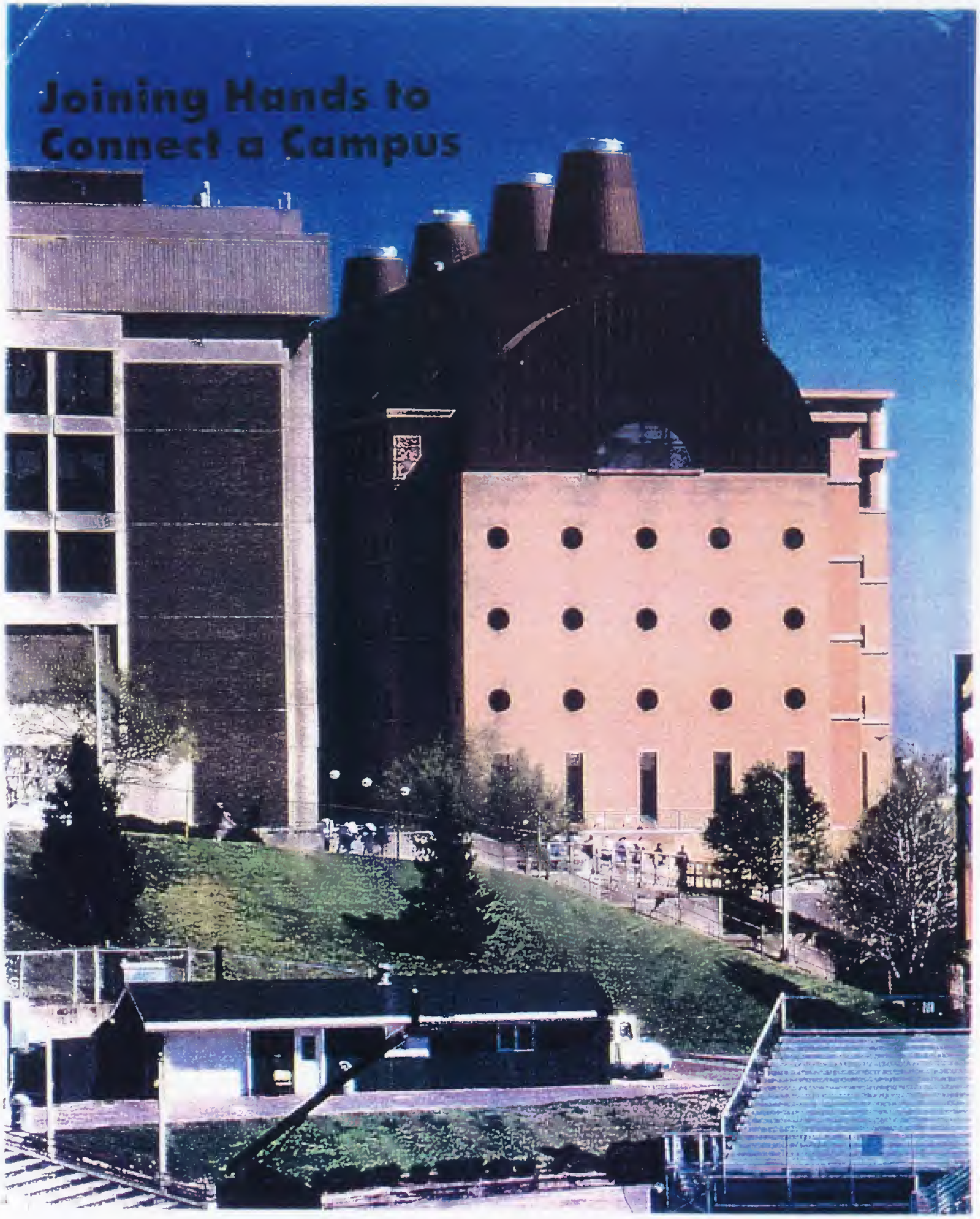
RON FORTH PHOTOS

EAST ELEVATION: Stacks and framing visible during construction.

NORTHEAST CORNER: Steel truss vault.

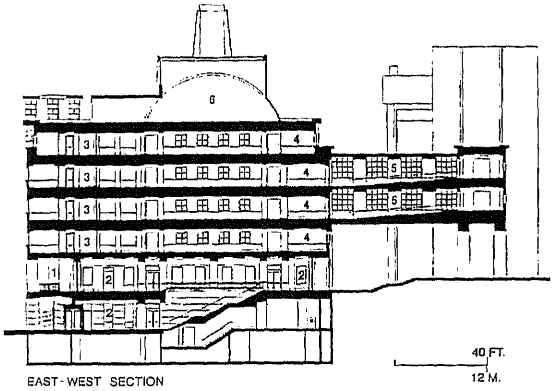


EAST-WEST SECTION: Value study saves $6 million without altering organization of labs (left) or bridge (right).

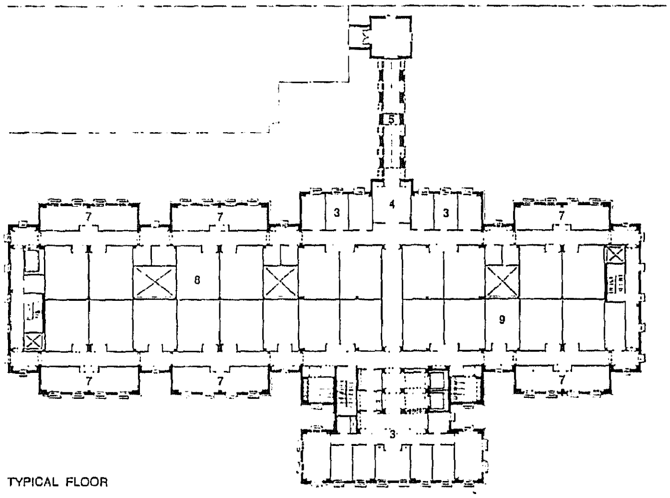


Joining Hands to Connect a Campus

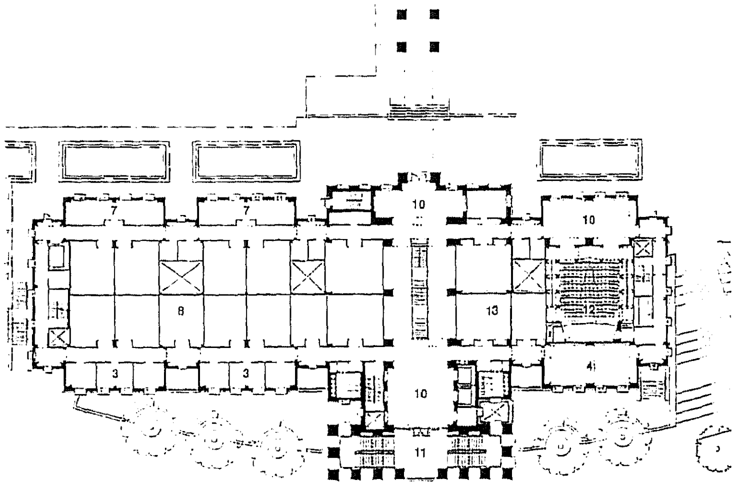
A new landmark on the University of Cincinnati campus houses scientific research and fulfills an important master-plan role.



EAST-WEST SECTION



TYPICAL FLOOR



Up Close

"More than half of prospective students make up their minds about enrollment in the first five minutes of seeing campuses they've chosen as candidates," notes university architect Ron Kull. Cincinnati's campus had become less than inviting. From a polite line of 19th-century buildings on a wooded ridge (left in site model), the campus had grown to a sprawling cacophony of haphazardly sited buildings in every conceivable style infilled with paved roads and parking.

Program: Give the campus functional and visual coherence through a system of infill construction while greatly increasing open green space and pedestrian circulation.

Solutions: Kull overlaid the existing plan with grids (or force fields) generated by the alignments of major existing buildings and site features. Prominent among them is the diagonal orientation of the U-shaped stadium. Its open end faces a ravine sloping down toward the isolated medical campus (upper right in model), suggesting a major pedestrian axis connecting the two areas. A large green will become part of these landscaped walks, replacing a parking lot in front of the Engineering Research Center (opposite, top left). Parking is moving into a garage now under construction. The center is the culminating view on another critical axis—the entry drive onto the main-campus from the east (right in model). The master-plan's "signature building blocks" in design or construction or built, include a performing-arts center, a medical-arts building at the entrance to the northeast campus, and the arts and architecture school.

Statistics: Planned student population: 3,500 students. Campus area: 164 acres. (Ohio State University with a similar number of students has 1,600 acres.)

1. Loggia
2. Lobby
3. Administration/ faculty offices
4. Meeting room/lounge
5. Bridge
6. Mechanical
7. Graduate student office
8. Wet laboratories
9. Dry laboratories
10. Lobby
11. Loggia
12. Lecture Hall
13. Seminar rooms

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Typical floors are split into wet labs to the south (top left) and dry labs to the north (above). Exposed utilities in both sections are routed around the ceilings and plugged into as needed from below in anticipation of frequent room reconfigurations to meet the needs of changing users and experiments. These overhead feeds allow partitions to be standard stud and drywall, the most economical construction to move when it does not contain pipes, wiring, and ducts.

Interchangeable casework units in wet labs were a cost-engineering option chosen by the users over piped liquid oxygen. The hung units allow for easier maintenance—a major consideration in all planning. Exterior and interior windows allow deep penetration of daylight within lab areas. A major pedestrian axis on the campus master plan passes through the research center's lobby (opposite) where it makes a one-floor grade change from front to back.

Credits
Engineering Research Center
University of Cincinnati
Cincinnati, Ohio
Owner: *The State of Ohio*
Architect and Engineer: *KZF Incorporated—Donald L. Cornett, project manager and*

Campus architect Ron Kull describes his ambitious master plan for the University of Cincinnati as a grid-like system of "force fields" (see Up Close). A keystone of this plan is the new Engineering Research Center. Three major design firms with specialized expertise developed successful working relationships to resolve its complexities.

The new building's users were not clearly defined when the university commissioned architect KZF to help in site selection and programming. Initially, the only requirement was for a facility where professors from diverse fields such as environmental biosciences and aerospace could carry out experiments with student help to further scientific knowledge. (Financing for these projects was to come through grants from public and private sources, part of which would go toward running the building.) To determine functional criteria, prospective faculty users toured other research facilities around the country and pondered how to make the building as flexible as possible, while still meeting exacting requirements. Their wish list included super-clean rooms for microelectronics with particle ratings down to class 10, vibration-free scanning-microscope environments, and non-polluting exhausts of contaminated air.

KZF brought in architect Smith, Hinchman & Grylls for its extensive experience with highly technical buildings and ability to offer the committee cost alternatives (such as a choice between piped liquid oxygen or moveable casework) within the $26.2- million budget. Early money-saving decisions included placing vibration-free spaces, including clean rooms, on the ground floor to support the required extra-heavy structure and placing air-handling units under the roof (section opposite), so pollutants exhaust directly through bundled stacks in the conical towers.

But the professors wanted more than advanced technology in their 173,000-square-foot building. "High-profile" design was a surprise that meshed well with Kull's master plan because of the highly visible, if narrow, site eventually selected (right, bottom) adjacent to the main engineering building. KZF called on a Cincinnati alumnus, architect Michael Graves who designed a clear internal-circulation pattern that brings daylight into both corridors and offices and cuts through the building with a two-story lobby tieing the building into the campus master plan (right, top). Graves clad the walls in blue stone and orange terra cotta, and used colored precast concrete lintels to span large openings. The barrel roof is copper. A high colonnade marks the main entry.

How did the relationships among three major firms work out? "It was almost intuitive at times," says KZF manager of operations William Wilson, describing how each firm's way of working became clear to the others. During design, representatives of the three firms met on-site for week-long workshops attended by representatives of the user committee, the university administration, and the state. The result? The architects received approvals quickly and completed design *and* construction documents within 11 months. Following this satisfactory experience, SH&G, Graves, and KZF are currently pursuing commissions in association with one or both of the other firms.

Would its users want anything different in the new research center? Professor Edward Grood, a member of the academic committee that determined requirements, says he would have liked to see a central corridor between labs (made difficult by the site's restricted width), and more breakout and meeting rooms (given up to meet budget and to maximize basic-function spaces). "There are always trade-offs," he notes. *Charles K. Hoyt*

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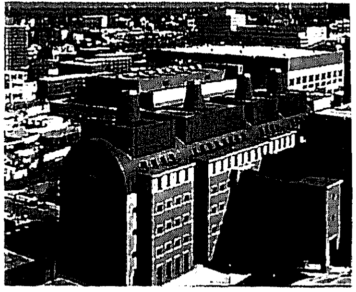
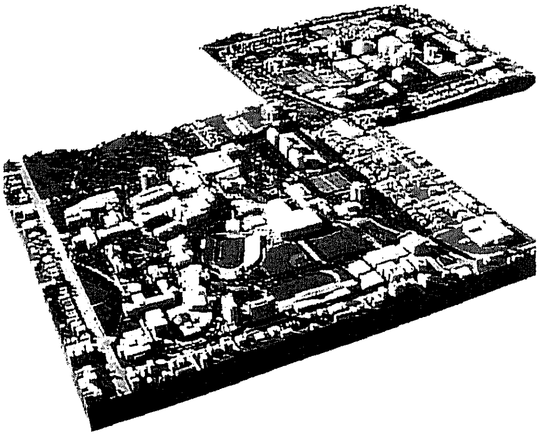


Architect Michael Graves aligned the building's front entrance—marked by a colonnaded office pavilion—with a major campus entry road (above). Inside, an internal stair (and elevator for the handicapped) makes a transition to an upper pedestrian circulation system. A bridge (top) connects the research building with the main engineering facility.



principal-in-charge; William H. Wilson, project architect; John R. Sheringer; Joseph C. Nader; project mechanical engineers; Jon A Bennett, project structural engineer; Joseph P. Oppold, project lighting and electrical engineer; William B. Sandmann, project electrical designer; Donald L. Schumer; site representative

Associated Architect: *Michael Graves, Architect—Michael Graves, design principal; Thomas Rowe, senior associate-in-charge; Keith McPeters, project manager; Mary Yun, job captain; Saverio Mango, Andrea Wang, designers*

Associated Architect and Engineer: *Smith Hinchman & Grylls—Andrew Vazzanio, planning principal; Jeff Hausman, project manager; John Flynn, lab architect; Stanley Mah, electrical engineer; Eric Kirkland, mechanical engineer; Stephen Kirk, costs and value engineer*

Consultants: *Hargreaves Associates (landscape); RWDI, Ltd. (wind-tunnel testing)*

Prime Contractors: *Monarch Construction (general); Banta Electric Contractors, Inc. (electrical); Peck, Hannaford, & Briggs Company (mechanical); Stark Plumbing (plumbing); Dalmation Fire, Inc. (fire protection)*

APPENDIX C

AN EXAMPLE OF A VALUE ENGINEERING STUDY DONE AT TISHMAN CONSTRUCTION CORPORATION, NY

Tishman Construction Corporation
Durst - 4 Times Square Office Building
Trade: Curtain Wall
September 30, 1996

Value Engineering Log

Item #	Date Originated	Description	Ref. Dwg. #	Proposed Amount	Action Required By	Status	Accepted VE	Rejected	Remarks
CW-101	9/19/96	Building Base - West Elevation at cylinder - Discrepancy exists in exterior wall type specified. Finish should be built in place stucco or EIFS.	A-301 Det.A7 specifies Type "F" Wall A-304 Det.A1 specifies Stucco	$350,000 add for metal panel	Fox&Fowle Tishman ($)	Open			Stucco finish is included in the budget numbers. Fox & Fowle currently shows 18" wide metal panels due to apprehension over using stucco for this application. Fox & Fowle to research if stucco is practical at this location.
CW-102	9/19/96	Construct 43rd Street entrance at cylinder in segmented, not curved aluminum panels.	A-311 Det. L1	T.B.D.	Fox&Fowle	Resolved	Accepted		Entrance panels are segmented, and will be purchased in Storefront, not Curtainwall Contract.
CW-103	9/19/96	Increase height of parapet walls, eliminate need for railing behind.	Various, incl. A-306, Det.A10,A13, N13 A-307,Det.A17 A-308,Det.A5	($100,000)	Durst Fox&Fowle	Resolved		Rejected ($100,000)	Parapet walls will remain as shown. Raising parapet height will obscure vision from office area at setback roofs. Tishman to price purchase of aluminum railing attached to parapet from Curtainwall Contractor.

CW-104	9/19/96	Simplify recessed spandral condition at Base of building.	A-309,Det.A18, K14	T.B.D.	Durst Fox&Fowle	Resolved		Rejected	Recess has been reduced in latest drawing issue, however detail will remain. **Additional Note:** Tishman will purchase alternate price for eliminating recess in areas behind Broadway signage.
CW-105	9/19/96	Specify/ detail alternates to Pilkington system at Main Entrance.	A-305,Det.A1	($75,000)	Fox&Fowle	Open			Fox & Fowle to meet with other storefront manufacturers to design an entrance that is compatible with other manufacturers.
CW-106	9/19/96	Simplify canopy construction/ details at Main Entrance	A-308,Det.A10	($100,000)	Durst Fox&Fowle	Bidding Strategy Resolved			Fox & Fowle to design an alternate canopy system to be purchased as an alternate during storefront purchase.
CW-107	9/19/96	Replace curved panels at 42nd Street & Broadway Entrance with segmented panels.	A-310,Det.S10	($250,000)	Durst Fox&Fowle	Bidding Strategy Resolved			Current design is radial glass panels. Tishman to purchase deduct alternate for changing to segmented glass.
CW-108	9/19/96	Typical Louver Section at Broadway Curve calls for Stainless Steel trim attached to Curtain Wall panel at the floor above. Substitute #4 Brushed finish aluminum at this location.	A-309,Det.K14	T.B.D.	Fox&Fowle	Resolved	Accepted		Drawings to be revised to show aluminum trim. **Additional Note:** As of 9/23/96, Stainless Steel Trim still shown on drawings.
CW-109	9/19/96	Section at Shadow Box - Supporting steel should be straight, not curved.	A-306,Det.A13	T.B.D.	Fox&Fowle	Resolved	Accepted		Details of construction at that location will be a performance criteria only. Contractor to decide on specific method of construction.

CW-110	9/19/96	Plan Detail calls for construction of shadow box at corner, consider substituting spandral glass at this location.	A-310,Det.A10	T.B.D.	Fox&Fowle	Resolved	Accepted		Shadowbox detail to be eliminated - corner will be "sealed up" with drywall from the inside. **Additional Note:** Detail revised on 9/23/96 drawings.
CW-111	9/19/96	Lower performance paint should be specified for interior surfaces of exterior wall.	Specifications	T.B.D.	Durst Fox&Fowle	Resolved	Accepted		To be incorporated into specifications.
CW-112	9/19/96	Replace cylindrical column enclosures with square, drywall enclosures.	Various A-107,Det.S7	($190,000)	Durst Fox&Fowle Tishman ($)	Open			Column enclosures to be "squared off" at all interior and tower locations. Curved column enclosures will remain at Base of building. (Tishman to supply price for curved column enclosures). **Additional Note:** Many columns have been "squared-off" on 9/23/96 drawing issue.
CW-113	9/19/96	Move blind pocket to location between window mullions.	A-313,Det.L5	($300,000)	Durst Fox&Fowle	Resolved		Rejected ($300,000)	Blind pocket must remain as designed due to tenant requirements.
CW-114	9/19/96	Consider changing stainless steel trim at Curtain Wall to aluminum.	A-306,Det.A10	($125,000)	Durst Fox&Fowle	Bidding Strategy Resolved			Tishman to price all aluminum trim as an alternate in contract.

CW-115	9/19/96	Top of Building Behind Signage - Use conventional metal siding in lieu of metal panels.	Various	($125,000)	Fox&Fowle	Resolved	Accepted ($125,000)		Area around louvers will be Curtainwall and included in Curtainwall package. All other areas to be metal panel and be bid as an alternate in the Curtainwall package. Change to drawings will not be made until end of October. **Additional Note:** Concern was raised over box trim detail application at metal panels. Fox & Fowle to review alternate trim configuration.
CW-116	9/19/96	Eliminate shadow boxes at all Type "B-2" curtainwall locations.	A-301	T.B.D.	Fox&Fowle	Resolved	Accepted		Shadowbox details may not be visible at 47th Floor. **Additional Note:** Drawings not yet revised as of 9/23/96.
CW-117	9/19/96	Replace curved wall panels at 48th floor Mechanical Penthouse with segmented metal panel system.	A-114	($375,000)	Fox&Fowle	Resolved	Accepted ($375,000)		See CW-115.
CW-118	9/19/96	Replace metal panel facade on roof penthouse with industrial metal panel, EIFS, stucco on block.	A-115	($300,000)	Fox&Fowle	Resolved	Accepted ($300,000)		See CW-115.
CW-119	9/19/96	Simplify stair tower structure at top of building.	Various	($250,000)	Durst Fox&Fowle	Open			Stair as currently designed is pre-fabricated sections bolted together on site, structure to be reviewed again after 9/23 drawing issue.

CW-120	9/19/96	Replace metal panel wrapped steel at top of building with painted structural steel. Simplify detailing.	A-302	($750,000)	Durst Fox&Fowle	Resolved	Accepted ($750,000)		Drawings currently being revised to show exposed steel (welded box beams). Large cross-bracing members must remain to hold up catwalks in Mechanical areas. **Additional Note:** Drawings revised as of 9/23/96.

Tishman Construction Corporation
Durst - 4 Times Square Office Building
Trade: Mechanical/ Electrical/ Plumbing
September 30, 1996

Value Engineering Log

Item #	Date Originated	Description	Proposed Amount	Action Required By	Status	Accepted VE	Rejected	Remarks
Plumbing P-101	8/27/96	Elimination of mid-zone tank and combine with high-rise roof tanks.	($35,000)	N/A	Resolved		($35,000)	Mid-zone tanks must remain due to fire regulations.
Electrical E-101	8/27/96	Use of PVC pipe at below grade switchboard feeders in lieu of galvanized steel	($70,000)	N/A	Resolved	($70,000)		Use of thin wall PVC is acceptable below grade as long as it is encased in lightweight concrete. **Additional Note:** Durst requested that the concrete sidewalk be tagged (with imbedded brass tacks) to indicate location of underground lines.
E-102	8/27/96	Use of all copper or aluminum for Bus Duct and risers (Current spec mixes materials)	Cost of copper approx. +20% over aluminum	N/A	Bidding strategy resolved			Bid Package will include Base price for all coppper. Alternate price will specify use of aluminum. Final decision pending pricing.
E-103	8/27/96	Possible combining the 2 electrical closets on Floors 27 and up into 1 closet on each floor	($100,000) -cost of altering existing closet	Tishman	Resolved		($100,000)	Combining 2 closets into one will require tenants to run longer homeruns on a floor, but will eliminate cost of constructing 2nd closet by Owner. **Note: (As of 8/30/96)** This will probably not be a feasible change, single closet as currently designed, would not be of sufficient size to combine the 2.
HVAC M-101	8/27/96	Combine EF-1and EF-6 into one system (Ref Dwg. M-101)	($4,000)	Cosentini	Open			Combination possible in the storage areas, Cosentini to check if Switchgear Room requires separate Exhaust.

M-102	8/27/96	Combine the following into single systems: -SF-2 & SF-1(Ref. Dwg. M-101) -SF-5 & SF-9 (Ref. Dwg. M-102) -EF-10 & EF-11(Ref. Dwg. M-102)	($4,000) ($6,000) ($6,000)	Cosentini	Resolved	($4,000) ($6,000) ($6,000)		Cosentini to review and revise drawings - air/water supply to be distributed via "shortest run" to all tenant areas- services to be brought to one central location for tenant tie-in
M-103	8/27/96	Delete West to East duct run on EF-4 and combine with EF-5 into one system (Ref. Dwg. M-101)	($14,000)	Cosentini	Open			Duct Run to be made smaller, Cosentini to review condition investigate combining into one system.
M-104	8/27/96	Eliminate run outs on outside air duct and EF-12 (Ref. Dwg M-102)	($20,000)	Cosentini	Resolved	($20,000)		Run outs to be eliminated, duct to be brought to face of wall only. Cosentini to revise drawings.
M-105	8/27/96	Elimination of unit heaters at cellar storage areas (Ref. Dwg. M-102)	($20,000)	Cosentini	Resolved	($20,000)		Unit heaters to be eliminated from drawings at Subcellar, Cellar Storage areas. Only heaters at Water Service Room to remain.
M-106	8/27/96	Combine (horizontal only) 46x30 and 54x30 ducts into one duct (Ref. Dwg M-104)	($4,000)	Cosentini Fox & Fowle	Open			Cosentini, Fox & Fowle to review.
M-107	8/27/96	Eliminate distributed piping valved outlets and unit heaters at third floor retail spaces (Ref. Dwg. M-105)	($30,000)	Tishman	Bidding Strategy resolved			Unit heaters must remain. Electric unit heaters to be purchased as alternate in contract. If tenant space is leased prior to installation, a deduct will be taken for the unit heaters.
M-108	8/27/96	Use outside air riser as smoke exhaust riser.	($125,000)	N/A	Resolved		($125,000)	These 2 risers cannot be combined due to operational requirements.
M-109	8/27/96	Substitute schedule 40 for schedule 80 pipe on open condenser water loop.	($70,000)	Tishman	Bidding Strategy Resolved			Deduct alternate to be specified in bid documents
M-110	8/27/96	Delete elevator lobby ductwork on Conde Nast floors	($18,000)	Cosentini	Resolved	($18,000)		Ductwork not required, just beam penetrations. Drawings to be revised.

M-111	8/27/96	Reduce size of refrigeration plant.	($350,000)	Cosentini Tishman	Resolved	($350,000)		500T machine to be eliminated. Reduce to 4 - 1000T machines. **Additional Note:** revision to be made to Lobby Cooling System - No cooling will be provided when the building is unoccupied.
M-112	8/27/96	Eliminate heat exchangers on the high rise hot water heating systems	($35,000)	Cosentini	Resolved	($35,000)		Roof heat exchangers to be eliminated, three way bleed valve to be used.
M-113	9/17/96	Specification #15880-15 "Air Distribution", Section H, Paragraph 2 calls for "All casings and plenums are lined with 2" of acoustical insulation with inner aluminum perforated liner..." Thiinsulation and lining can be eliminated on all outside air plenums only.	($22,000)	Cosentini	Open			

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