Short Course on
Value Engineering Concepts and Management

Date	:	Monday, 12 September 2005
Time	:	8.30 am - 5.30 pm
Venue	:	York Hotel
Organiser	:	Conferences and Seminars Committee
Speaker	:	Dr. Charles Cheah, NTU
CPD Programme	:	8 PDUs
Fees*	:	$180 (IES Members) $220 (Non-members)

- *Inclusive of 5% GST, course materials and refreshments.*
- *5 % discount will be given to companies that send 3 or more participants.*
- *Certificate of Attendance for participants with at least 75% Attendance*

Course Descriptions

According to SAVE International, value engineering (VE) can be defined as the systematic application of recognized techniques which identify the function of a product or service and provide the necessary function reliably at the lowest overall cost. For decades, public and private sectors in the United States and the United Kingdom have successfully applied the principles of VE to their advantage. The U.S. Department of Defense (DOD), for instance, has documented more than US$27 billion in VE savings in the past 20 years. With an increasing level of competition in the local and regional construction industry, VE represents a valuable tool to improve on the level of functionality, quality and cost-effectiveness of a product, project, or even system.

This 1-day course will cover the fundamental concepts of VE and clarify some of the myths and misconceptions about the topic. A systematic approach of applying VE, which consists of seven different phases, will be introduced. The application of the principles is supplemented by the use of examples and case illustrations. Since the application of VE is more successful in the U.S., U.K. and Japan, the course would also serve as an excellent avenue to exchange opinions and ideas on the prospect of VE in the local and regional context.

Course Outlines

Morning Session:

- Introduction to value engineering – A real case fast forward
- Brief background and history of VE
- Myths of VE – what it is and what it is not
- Fundamental concepts of value and cost
- Criteria of VE study and time of application in a project life cycle
- The Job Plan as a systematic VE approach – Overview of the Seven Phases
- Information phase
- Functional phase – functional analysis; cost models; FAST diagram

Afternoon Session:

- Creative phase – concept of fixation; team member selection; creative problem solving techniques; Delphi technique
- Remaining phases – judgmental; development; recommendation; implementation
- Organizational settings for VE Study
- Introduction to life-cycle costing and relevance to VE
- Case illustrations of VE application
- Discussion on the prospect of VE in the local and regional markets
- Past survey findings

Who Should Attend

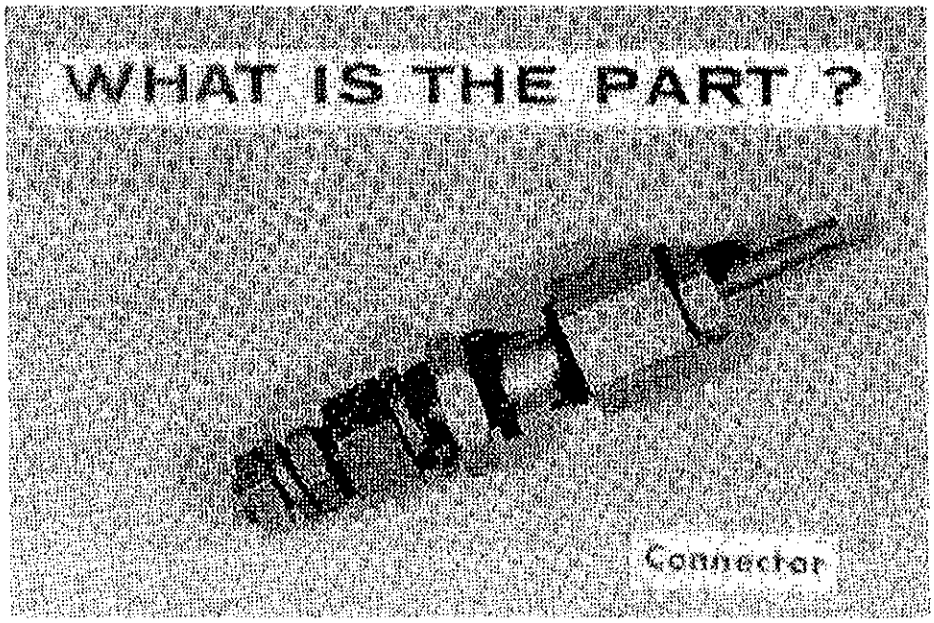
The one-day course is suitable for, but not limited to, construction industry professionals from both public and private sectors, including developers, architects, engineers, project managers, plant managers, contractors, quantity surveyors, and facility operators.

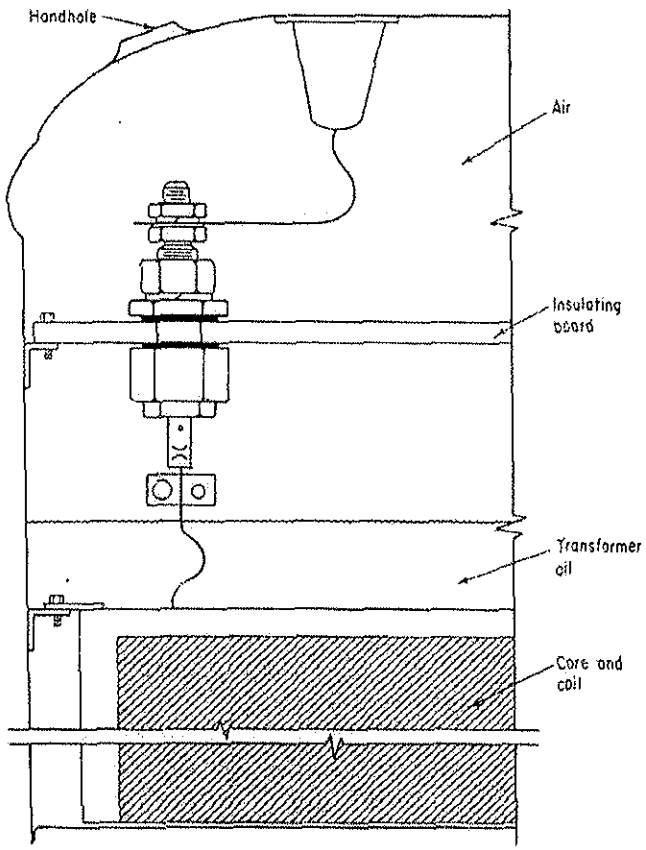
Speaker's Profile

Dr. Charles Cheah is currently an assistant professor under the Division of Construction Technology and Management at the Nanyang Technological University (NTU) of Singapore. His has previously worked as a structural design engineer in a consulting firm and also as a project engineer at ExxonMobil Corporation. Dr. Cheah's doctoral degree was conferred by the Massachusetts Institute of Technology (MIT), where he was a member of the Infrastructure System Development Research group. His research interest is broad and interdisciplinary in nature, and his publications have appeared in journals related to construction, finance, project management, and engineering education. In fact, one of his recent papers includes the "Appraisal of Value Engineering in Construction in Southeast Asia", which was published in the *International Journal of Project Management.*

In NTU, Dr. Cheah has conducted lectures for the value engineering module for more than 3 years now. He has also spoken in a series of seminars on corporate strategy in China. He is a regular member of the *American Society of Civil Engineers* and an affiliate member of the CFA Institute and the Singapore Society of Financial Analysts.

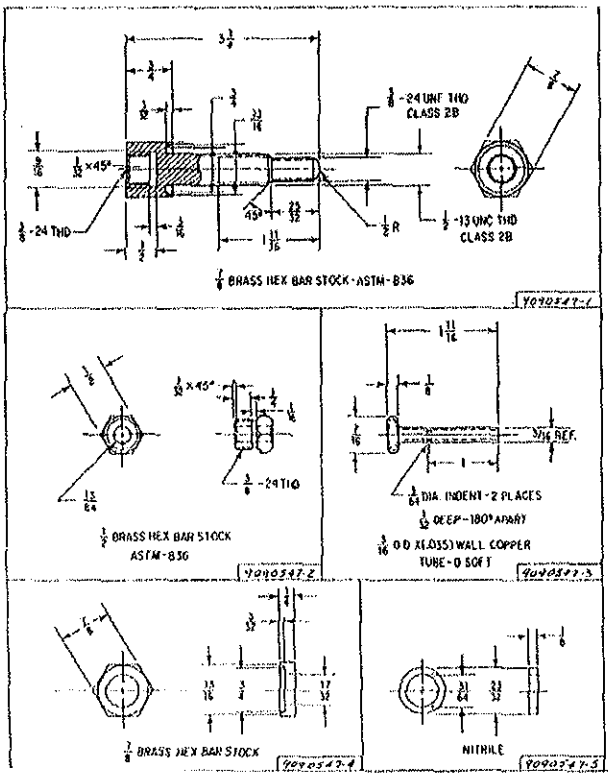
Introduction – A Real Case Fast Forward





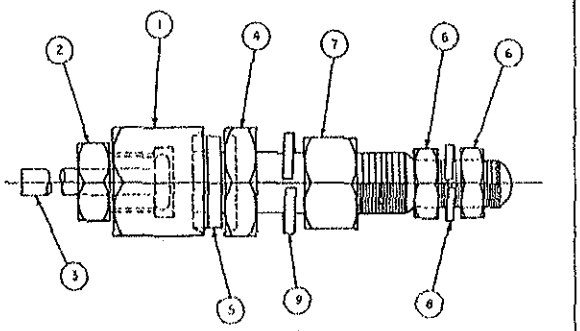
SPECIFICATIONS

1. Conduct current of 30 Amperes
2. Connections to lead wires must be readily disconnectable
3. Pressure generated in operation up to 7 p.s.i.
4. Complete unit subject to shipping and operational vibrations
5. Coil wires are 4¼ inch apart



BILL OF MATERIAL

QTY	PART NO	DESCRIPTION	FIND NO.
1	9090547-1	STUD, BRASS	1
1	9090547-2	NUT, BRASS	2
1	9090547-3	TUBE, SPT.	3
1	9090547-4	WASHER, RECESSED	4
2	9090547-5	GASKET	5
2	600020-4	NUT, HEX, BRASS - 3/8	6
1	600020-6	NUT, HEX, BRONZE 1/2	7
1	601120-4	LOCK WASHER - 3/8	8
1	601120-6	LOCK WASHER - 1/2	9



CONNECTOR
M.E.A. COMPANY
BETHEL PARK, PA
9090547

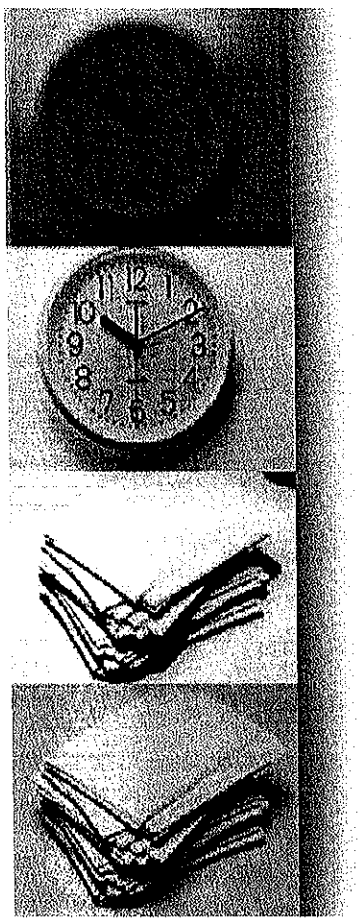
OPERATION SHEET

NAME Stud
SHEETS SHEET NO.
MFG. QTY. 25 PCS.
PART NO. 9090547-1
MATERIAL 7/8" Hex Brass - ASTM B36 x 3 1/2" long
DATE
DRG. NO.

DEPT.	OPER. SYMBOL	OPERATION DESCRIPTION	CUT	FEED	SPEED	MACH. NO.	TOOLS	STANDARD HOURS SET UP	STANDARD HOURS PER PIECE
	#1	Turret lathe							
		Bevel for mill box					Knee tool		Std
		Turn 1/2" dia. - 2 1/2" long					Mill box		Std
		Turn 3/8" dia. - 25/32" lg. w/45° bevel					Mill box		Std
		Cut grove under shoulder					Groove tool		Std
		Chase 1/2" - 13 thd to 11/16" dim					Chaser		Std
		Form 1/2" radius					Form tool		Std
		Chase 3/8 - 24 thd - 25/32" lg					Chaser		Std
		Cut off - 3 1/4" lg.					C.O. tool		Std
	#2	Remove tip at bench					Hand file		
							Subtotal	1.4 hrs	.05 hrs
	#3	Turret lathe							
		Spot drill					Spot drill		Std
		Drill - 5/16"					Drill		Std
		Bottom drill					Bottom Drill		Std
		Form relief					Rel. tool		Std
		Bevel for tap					90° Countersink		Std
		Tap 3/8 - 24 thd					3/8 - 24 tap		Std
		Bottom tap					" Bottom tap		Std
							Subtotal	1.00 hrs	.03 hrs
	#4	Burr complete					Burr bench		Std
							Subtotal	.10	.04
							Total	2.50 hrs	.120 hrs
							2.50 s.u. ÷ 25 = .10 hrs s.u./pc.		
							.120 D.L./pc = .120		
							.220 hrs/pc.		

Relation to Specifications	Quantity	Part number	Part name	Material	Labor	Burden	Total
	1	9090547	Connector				
1(1/3),2(1/3),3(1/3)	1	9090547-1	Stud, brass	$0.660	$0.660	$1.980	3.300
2	1	9090547-2	Nut, brass	0.142	0.354	1.062	1.558
2	1	9090547-3	Tube, special	0.228	0.525	1.575	2.328
3	1	9090547-4	Washer, recessed	0.075	0.324	0.972	1.371
3	2	9090547-5	Gasket, nitrile	0.262	0.210	0.630	1.102
2	2	600020-4	Nut, hex brass ⅜ in.	0.148	.....	.....	0.148
3	1	600020-6	Nut, hex bronze ½ in.	0.129	.....	.....	0.129
4	1	601120-4	Lock washer, ⅜ in.	0.004	.....	.....	0.004
4	1	601120-6	Lock washer, ½ in.	0.007	.....	.....	0.007
	Total ..	.....	.....	$1.655	$2.073	$6.219	9.947

Specification or Requirement	Relative Cost
1. 30-ampere input	$0.440
2. Connection and disconnection	$1.837
3. Seal opening	$1.404
4. Resist vibration	$0.011
TOTAL	$3.692



JOY JOY MANUFACTURING COMPANY Ref. No. MEA-1

FUNCTIONAL DEFINITION

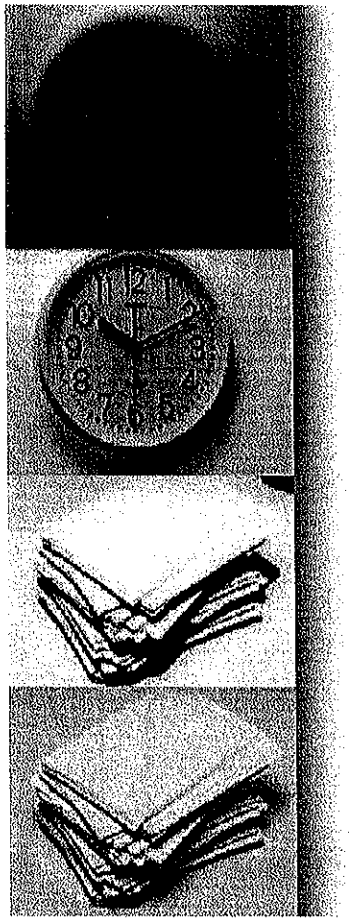
Project Connector Drawing No. 9090547

30 amps of current (Input) — Basic Function — 30 amps of current + heat (Output)

Qty.	Part	Function(s) Verb	Function(s) Noun	Func. Part B.	Func. Part S.	Level Assy. B.	Level Assy. S.	Notes and/or Comments
2	⅜" Brass nuts 600020-4	Establish Control Apply Conduct Resist	Connection Location Pressure Current Pressure					Must be readily disconnectable.
1	⅜" Lock washer 601120-4	Transmit Induce Establish Resist	Pressure Friction Location Movement					Subject to shipping and operational vibration
1	½" Bronze nut 600020-6	Apply Control	Pressure Location					
1	½" Lock washer 601120-6	Transmit Induce Establish Resist	Pressure Friction Location Movement					Subject to shipping and operational vibration.
1	Recessed washer 9090547-4	Create Transmit	Location Pressure					
2	Gaskets 9090547-5	Create Control Transmit Provide	Seal Location Pressure Connection					Must withstand 7 PSI pressure
1	Stud, brass 9090547-1	Provide Create Conduct Resist Transmit	Connection Location Current Movement Pressure					Must fit through ½" hole
1	Nut, brass 9090547-2	Create Conduct Establish Apply	Location Current Connection Pressure					Must be readily disconnectable
1	Tube, special 9090547-3	Establish Create Transmit Conduct	Connection Location Pressure Current					

Team Members _____ Date _____

Form No. [illegible] 11-[illegible] VALUE ENGINEERING



PROJECT Connector DRAWING NO. 9090547

30 amps of current (INPUT) — BASIC FUNCTION — 30 amps of current + heat (OUTPUT)

QTY.	PART	FUNCTION(S) VERB	FUNCTION(S) NOUN	FUNC. PART B.	FUNC. PART S.	LEVEL ASSY. B.	LEVEL ASSY. S.	NOTES AND/OR COMMENTS
2	3/8" Brass nuts 600020-4	Establish Control Apply Conduct Resist	Connection Location Pressure Current Pressure	✓	✓ ✓ ✓ ✓		(3)	Must be readily disconnectable
1	3/8" Lock washer 601120-4	Transmit Induce Establish Resist	Pressure Friction Location Movement	✓	✓ ✓ ✓		(4)	Subject to shipping and operational vibration
1	1/4" Bronze nut 600020-6	Apply Control	Pressure Location	✓	✓		(5)	
1	1/2" Lock washer 601120-6	Transmit Induce Establish Resist	Pressure Friction Location Movement	✓	✓ ✓		(4)	Subject to shipping and operational vibration
1	Recessed washer 9090547-4	Create Transmit	Location Pressure	✓	✓		(6)	
2	Gaskets 9090547-5	Create Control Transmit Provide	Seal Location Pressure Connection	✓	✓ ✓ ✓		(2)	Must withstand 7 P.S.I. pressure
1	Stud, brass 9090547-1	Provide Create Conduct Resist Transmit	Connection Location Current Movement Pressure	✓	✓ ✓ ✓ ✓	(1)		Must fit through 1/2" hole
1	Nut, brass 9090547-2	Create Conduct Establish Apply	Location Current Connection Pressure	✓	✓ ✓ ✓		(3)	Must be readily disconnectable
1	Tube, special 9090547-3	Establish Create Transmit Conduct	Connection Location Pressure Current	✓	✓ ✓ ✓		(3)	

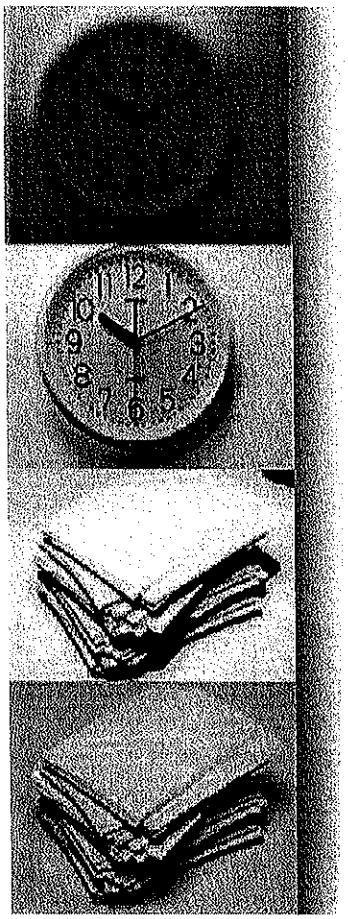
Conclusion from Functional Evaluation

1. Of the 34 individual part functions, only 9 are basic to an individual part.
   - Of these nine, three are performed by two or more parts and only one is basic to the whole assembly
2. There are cases where one part performs multiple functions necessary to the present assembly - the stud.
3. Redundant functions, such as "establish connection" and "create location", can be seen throughout the assembly, and all are suspected of adding unnecessary cost.

Conclusion from Functional Evaluation

4. There are at least two levels of 2nd degree functions: those required due to specifications and those due to the present approach.
5. The only functions which the team must concentrate on throughout the rest of their study are the basic function and the secondary functions needed to fulfill specifications.

- Question is how to accomplish the necessary functions in a different manner while still retaining the required reliability, quality, and maintainability



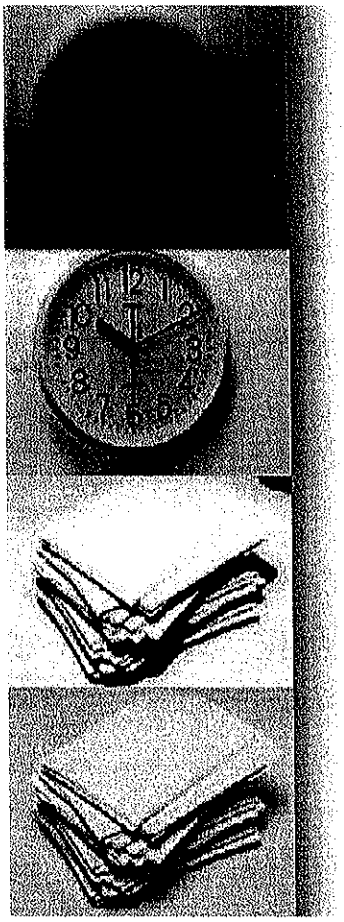
JOY MANUFACTURING COMPANY

Rev. No. MEA-1

CREATION WORKSHEET

FUNCTION Conduct current

1. Wire	24. Electrolyte
2. Bolt	27. Aluminum
3. Welding rod	28. Ions
4. Water	29. Liquid
5. Air	30. Oil
6. Iron	31. Lead
7. Steel	32. Zinc
8. Brass	33. Tube
9. Copper	34. Pipe
10. Paper clip	35. Wood
11. Nail	36. Fuse
12. Laser	37. Socket
13. Magnetic field	38. Plug
14. Rod	39. Washer
15. Screw	40. Transistor
16. Nut	41. Solution
17. Clip	42. Heated glass
18. Tape	43. Foil
19. Plastic	
20. Human body	
21. Bar	
22. Carbon	
23. Radiate	
24. Gas	
25. Dirt	



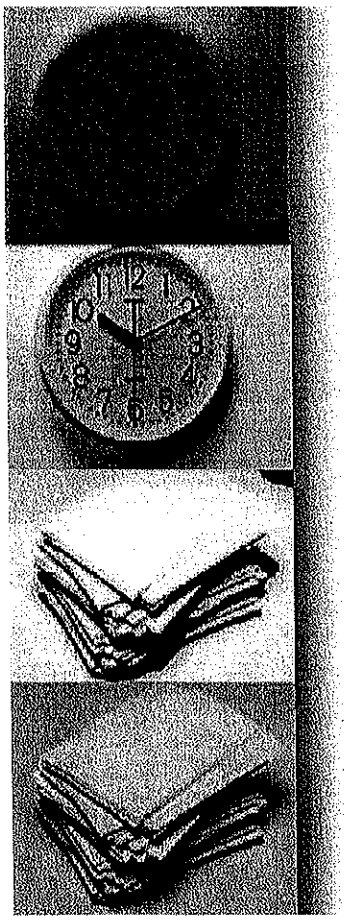
JOY MANUFACTURING COMPANY

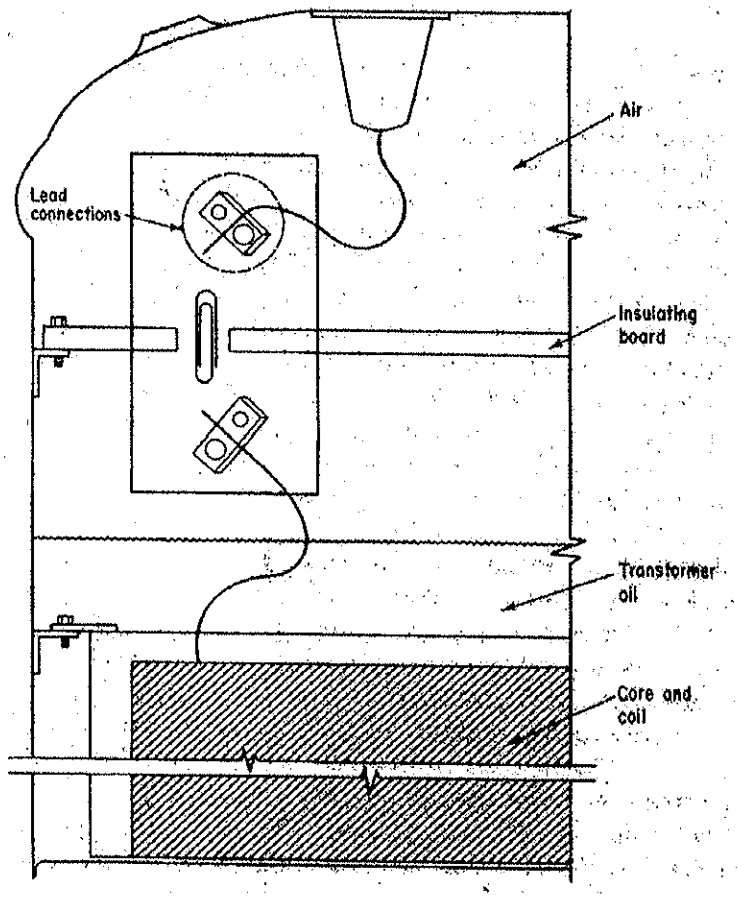
Rev. No. MEA-1

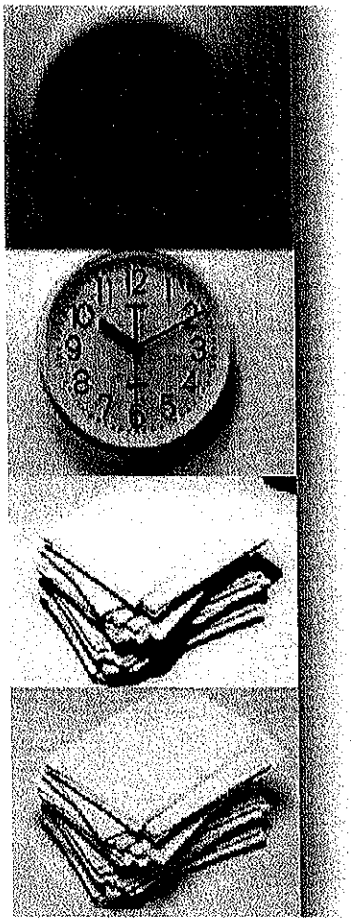
CREATION WORKSHEET

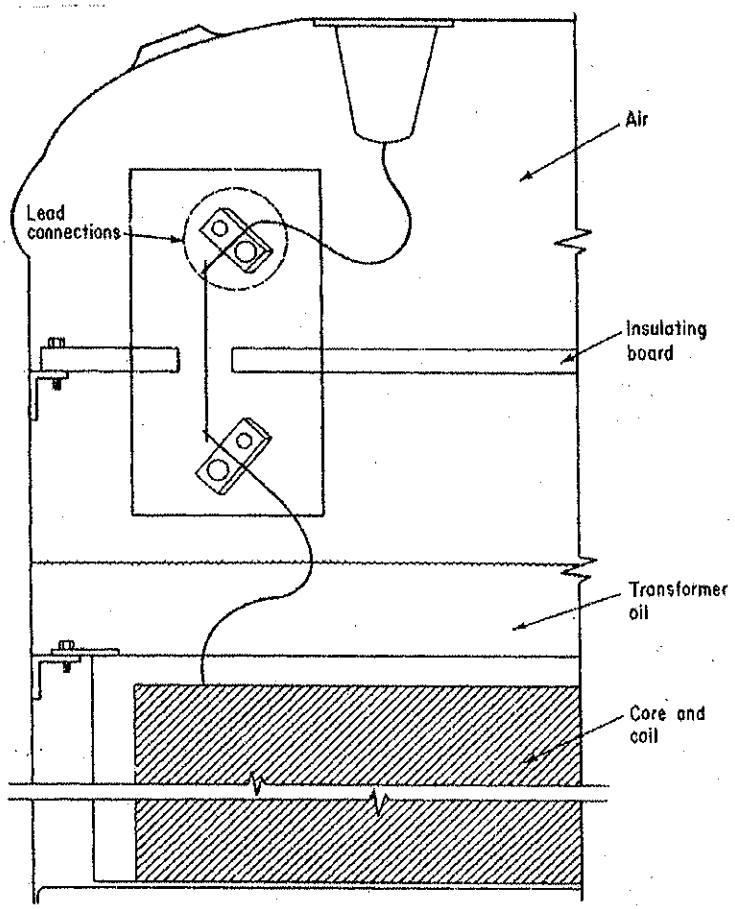
FUNCTION Create seal

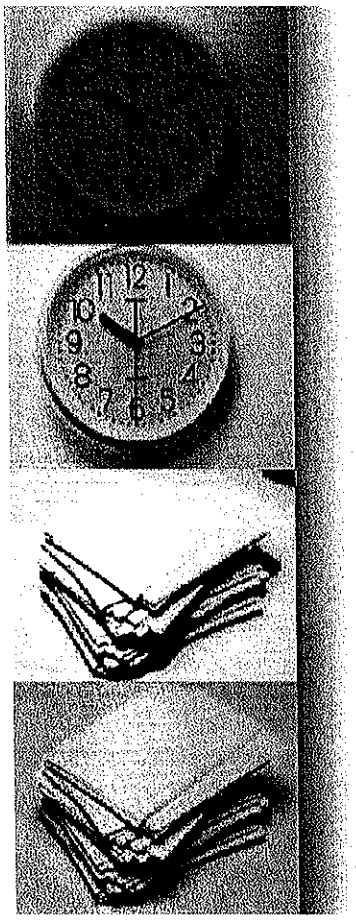
1. Paint	26. Braze
2. Rubber	27. Plate
3. Ring	28. Solder
4. Plug	29. Glass
5. Dried blood	30. Vacuum
6. Varnish	31. Spigot
7. Glue	32. Labyrinth
8. Plastic	33. Water
9. Epoxy	34. Dove tail
10. Wax	35. Cork
11. Pitch	36. Flange
12. Chrome	37. Paper
13. Weld	38. Rod
14. Rivet	39. Foam plastic
15. Fit	40. Stopper
16. Washer	
17. Soap	
18. Gasket	
19. Leather	
20. Grease	
21. Air	
22. Heat	
23. Freeze	
24. Compress	
25. Expand	

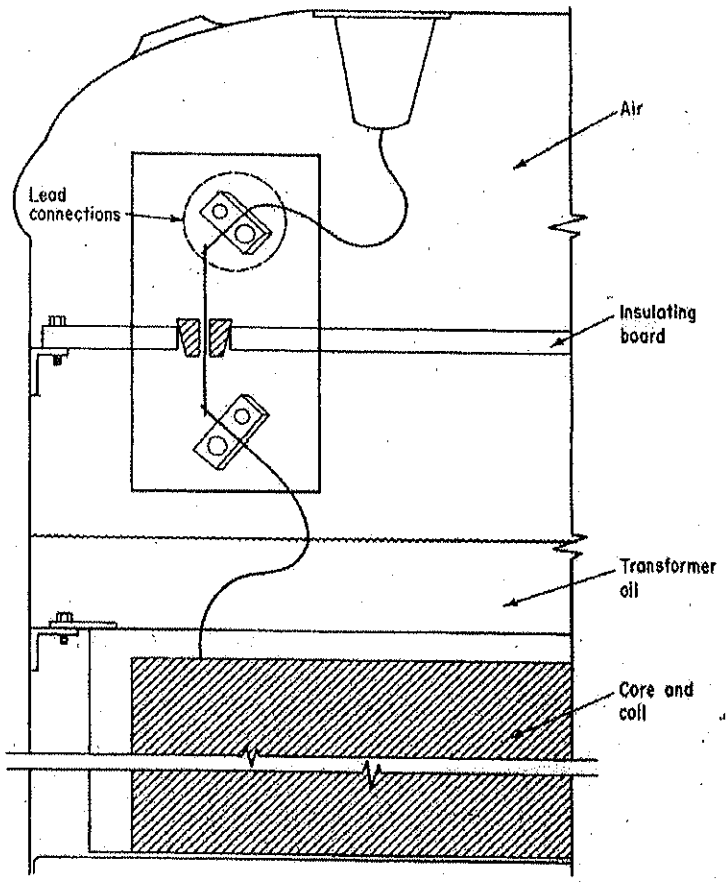


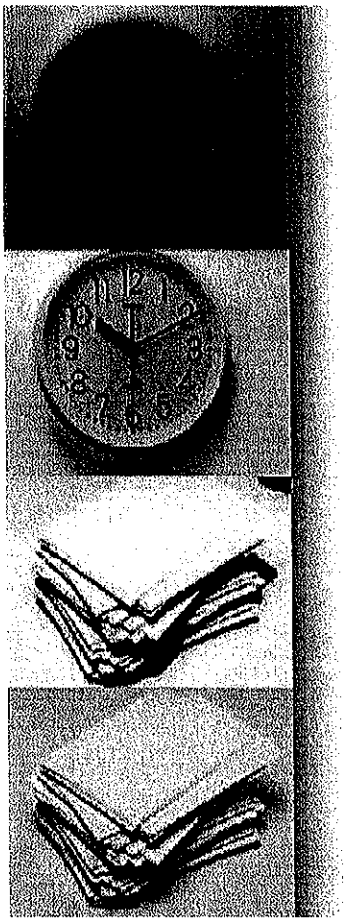


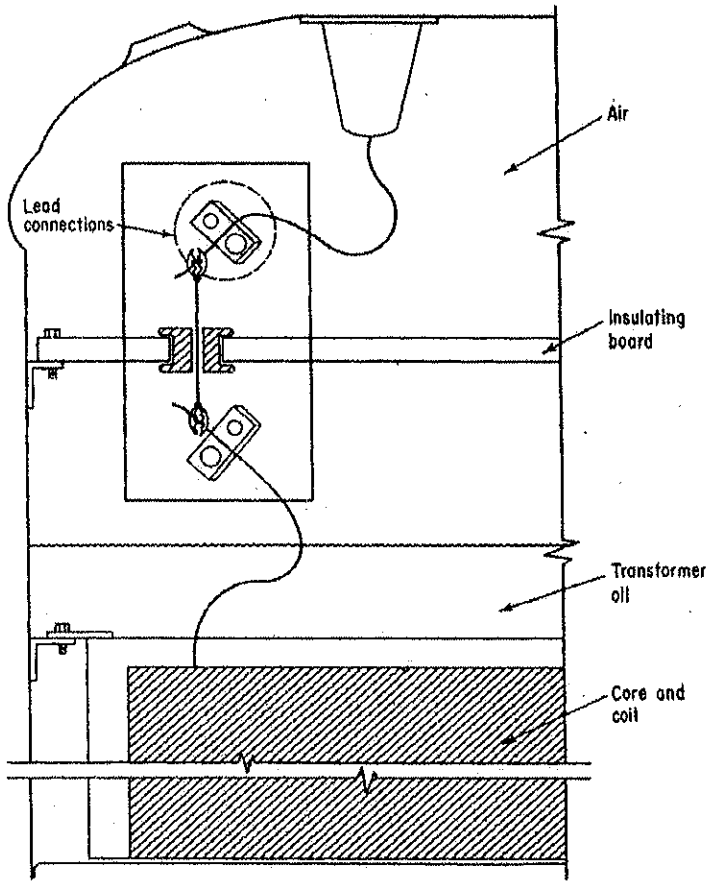


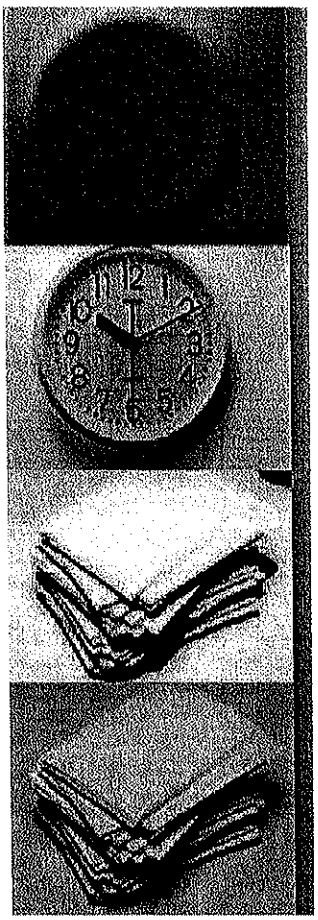

Air
Lead connections
Insulating board
Transformer oil
Core and coil




Air
Lead connections
Insulating board
Transformer oil
Core and coil







JOY MANUFACTURING COMPANY

Ref. No. MEA-1

FUNCTIONAL DEVELOPMENT

Basic Function: Conduct current

FUNCTION	CREATIVE IDEA(S) & DEVELOPMENT	ESTIMATED COST (CUMULATIVE)
① Conduct current	Paper clip	$.001
4 1/4" between leads	Paper clip - bend straight - 4 1/2" long	$.01
30 amps of current	Change above to 8 gauge wire	$.02
② Create seal	Rubber stopper with hole to accept wire as force fit.	$.07
7 P.S.I.	Reverse stopper so pressure forces into hole	$.07
Shipping vibration	Change stopper to double flanged grommet	$.12
1/2" hole	Grommet fits hole - no change	$.12
③ Establish connection	Use clip on each end 8 gauge wire (alligator type)	$.20
Disconnectable	No change required	$.20
Shipping vibration	No change required	$.20
④ Induce friction	No modification required	$.20
⑤ Apply pressure	No modification required	$.20
⑥ Transmit pressure	No modification required	$.20

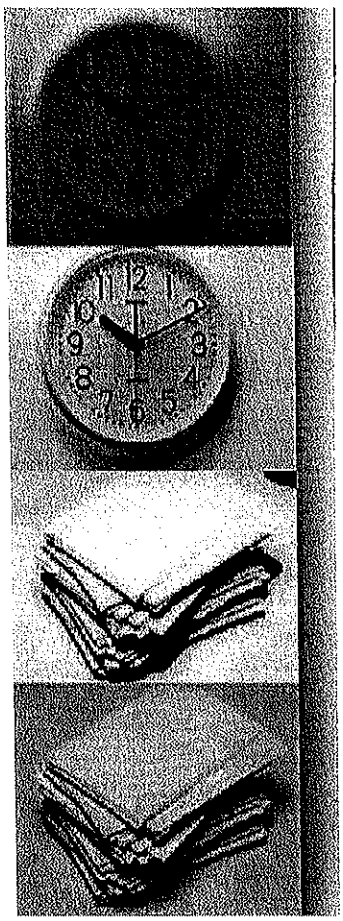
JOY MANUFACTURING COMPANY

Ref. No: MEA-1

IDEA EVALUATION

FUNCTION: Conduct current

IDEA FROM FUNCTIONAL DEVELOPMENT	ADVANTAGES	DISADVANTAGES
Conduct current through a half inch thick insulating panel with an 8 gauge wire. A rubber grommet having a press fit hole for the wire and being a press fit in the insulating panel will form the required seal. Two alligator clips, fastened to the 8 gauge wire, will be used to connect and disconnect the assembly and the leads.	A. Low cost B. Simple in design C. Parts readily obtainable D. Maximum of two parts drawings required E. Number of assembly parts reduced from 11 to 4 F. Reduction of number of parts to be stocked G. Only grommet may be special and require drawing H. Simple to assemble in plant I. Assembly is interchangable with present design J. Assembly will work and will perform all the necessary functions	1. Seal may release under pressure. Should be tested 2. Alligator clips will have to be fastened to wire at assembly – might be problem in manufacturing. 3. Wire could slip through grommet, which would require panel disassembly 4. Due to shipping and operational vibrations, 8 gauge wire and connectors may be too small.



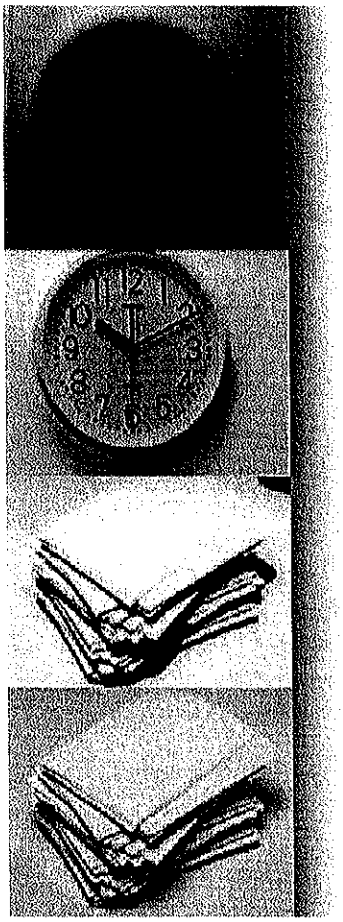
JOY MANUFACTURING COMPANY

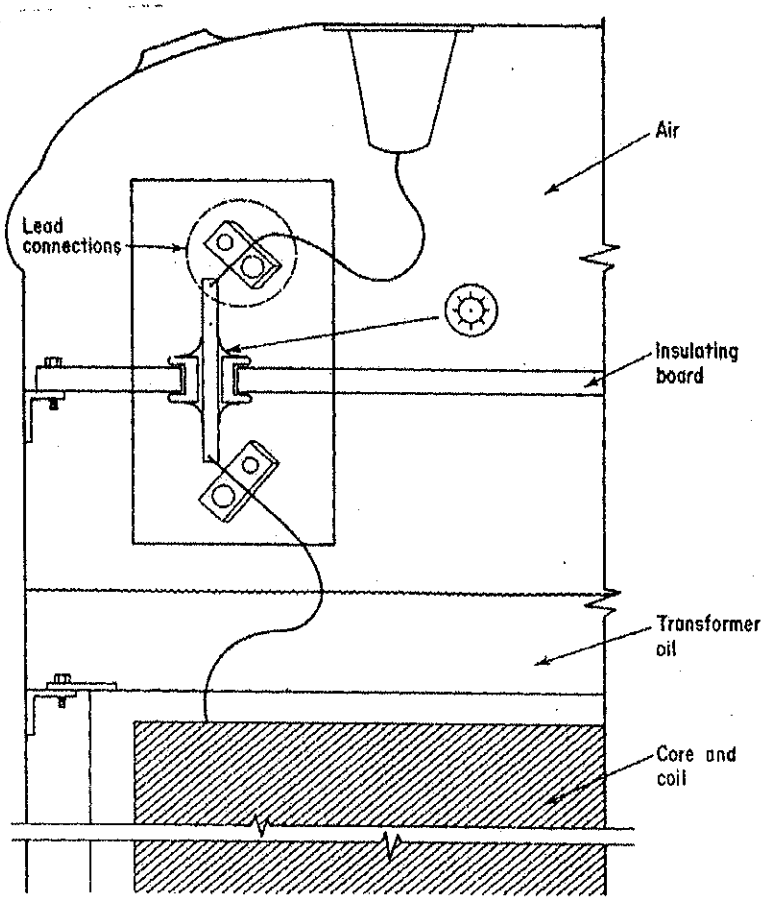
Ref. No. MEA-1

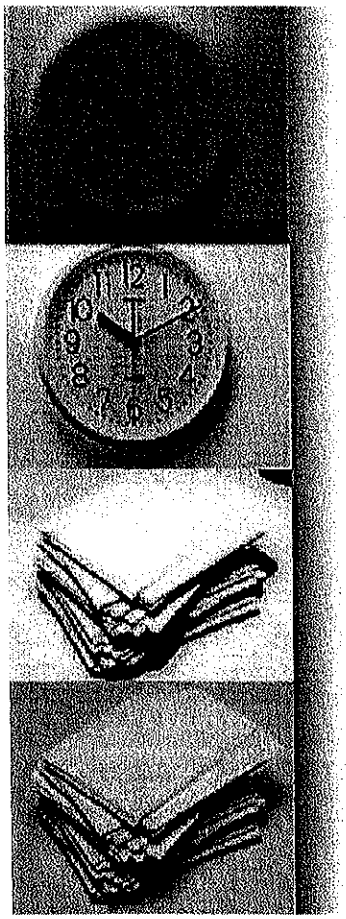
FUNCTIONAL DEVELOPMENT

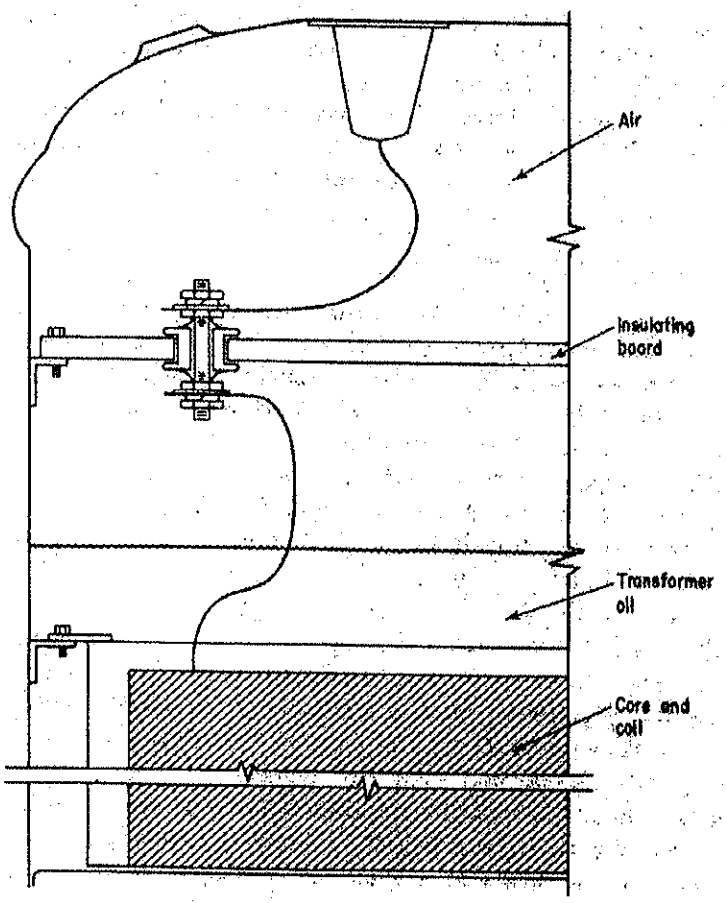
BASIC FUNCTION: Conduct current

FUNCTION	CREATIVE IDEA(S) & DEVELOPMENT	ESTIMATED COST (CUMULATIVE)	
① Conduct current	Paper clip	$.001	SELL
4 1/4" between leads	Paper clip - bend straight - 4 1/2" long	$.01	
30 amps of current	Change above to 8 gauge wire (1/4" diameter rod (brass) with spring clip for location)	$.02	$.14
② Create seal	Rubber stopper with hole to accept wire as force fit	$.07	
7 P.S.I	Reverse stopper so pressure forces into hole	$.07	
Shipping vibration	Change stopper to double flanged grommet	$.12	$.16
1/2" hole	Grommet fits hole - no change (Add 1 spring clip to aid in gasket retainment)	$.12	
③ Establish connection	Use clip on each end 8 gauge wire (alligator type)	$.20	
Disconnectable	No change required	$.20	$.40
Shipping vibration	No change required	$.20	
④ Induce friction	No modification required	$.20	$.40
⑤ Apply pressure	No modification required	$.20	$.40
⑥ Transmit pressure	No modification required	$.20	$.40




Air
Lead connections
Insulating board
Transformer oil
Core and coil




Air
Insulating board
Transformer oil
Core and coil

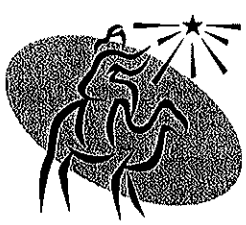
Morale of the case?

1. Know your constraints (specifications)
2. Focus on functions, not parts
3. Let ideas flow!!
4. Interdisciplinary team approach
5. Reality / practicality check

The shrewd man looks ahead
The simple man looks up
The resigned man looks down
The frightened man look behind

Only the wise man looks within

- Sydney J. Harris



VALUE ENGINEERING CONCEPTS & MANAGEMENT

Speaker: Dr. Charles Y.J. Cheah

Introduction to Value Engineering

- Background & History to VE
- Basic Concepts & Terminology

Why do we need to know history?

- A person seldom can make a proper judgment about a technique unless he knows how it developed
- Understand the limitation of the technique based on the circumstances faced by original inventor
- Understand where the unexplored territory lies so future improvements to technique can be made

Origin of Value Engineering

- Initial development of concept was a product of General Electric
- Developed by Lawrence Miles, an electrical engineer assigned to the purchasing department
- Materials shortage due to war effort – steels, aluminum, copper, nickel
- Same functions, but method of providing those functions have changed to accommodate situation

Origin of Value Engineering

- More cost conscious, willingness to experiment alternatives
- As the program developed, other subjects were added
  - Creative thinking
  - Evaluation of basic functions
  - Innovative development for new materials / methods / processes
  - Life cycle costing
  - Target costing and supply chain issues

Origin of Value Engineering

- Lawrence Miles called his program *Value Analysis*
- U.S. Navy, after being introduced, named it *Value Engineering* since they thought that the program should be applied at the engineering stage before the final product was built

Origin of Value Engineering

- DOD followed suit, asked suppliers to implement VE program but unsuccessful initially – contractual terms needed amendment: percentage sharing of savings from VE
- Abroad: Japan in 1970, Italy in 1978, Australia in 1979, Canada in 1978. Construction-oriented value engineers exist in Japan, India, South Africa, England, France, Sweden, and Germany

Value Engineering in Construction

- Concept first introduced into the U.S. Navy Facilities Engineering Command through introduction of DOD VE incentive provisions in construction contracts
- Initiated in a shipbuilding program in 1955
- Main objectives
  - Take advantage of contractor know-how
  - Improve criteria
  - Provide a contractual means to share savings

Value Engineering in Construction

- Contractors bid on contract documents which include VE sharing provisions (which do not affect the basis of the bid)
- After award, successful contractor to submit VE change proposals to the government for changes to his contract that effect contractual savings
- Fixed-price procurement contracts
  - Proposals on a voluntary basis with a 50/50 sharing

Value Engineering in Construction

- Negotiated procurement contracts
  - Government pays the contractor to engage in a VE program and share savings at a smaller percentage
  - More suitable for the case of Design-Build
  - Contractor-designer able to challenge government standards and criteria and program requirements

Some Definitions of VE

- A structured and concentrated cost control technique for identifying opportunities of cost reduction or value enhancement (Mudge, 1990)
- 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 (Society of American Value Engineers)
- A systematic approach to seek out the best functional balance between cost, reliability and performance of a product or project (Zimmerman & Hart, 1982)

A Practical Motivation for VE

- Inflation alone will double the costs of construction every 10 to 15 years. This has been the trend in the U.S. over the past 80 years.
  - Cost savings become naturally important. Value engineering helps to curb this inflation.
- What can potentially make Value Engineering important?
  - Increased competition
  - Increased customer's / client's expectations

What Value Engineering *IS*

- System Oriented – a formal job plan to identify and remove unnecessary costs
- Multi-disciplined Team Approach – teams of experienced designers and VE consultants
- Life-Cycle Oriented – examines the total cost of owning and operating a facility
- A proven management technique
- Function Oriented – relates function required to the value received

www.wisc.edu/wondt/miles www.value-eng.org www.hkivanhk/links.htm

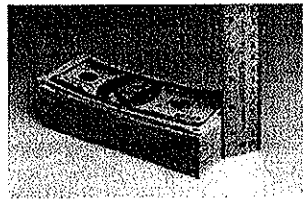
What Value Engineering *IS NOT*

- Design Review – it is not intended to correct omissions made in design, nor to review calculations made by the designer
- A Cheapening Process – it does not cut cost by sacrificing needed reliability and performance
- A Requirement Done on All Designs – it is not part of every designer's scheduled review, but a formal cost and functional analysis
- Quality Control – it does more than review fail-safe reliability status of plant or product design

Principal concepts

- The principal concepts which underlay the Value Engineering methodology are:
  - Function
  - Quality
  - Worth
  - Cost

} VALUE



The Value Concept

- Value is the worth of a product or service in terms of usefulness or importance to a buyer; lowest cost to reliably provide the functions of service at the desired time and place with essential quality
  - E.g. what is often implied by the statement "good value for money"?
- Value can be increased by either:
  - Increasing performance / quality
  - Reducing cost

The Value Concept

- Value $= \frac{Function}{Cost}$
  - From the perspective of producer
- Value $= \frac{Perceived\ Benefit}{Price}$
  - From the perspective of customer / client

The Quality Gap

•What they think is good •What is reputed to be good •What experience says is good	•Physical properties •Mechanical properties •Actual performance

•Gap between the two

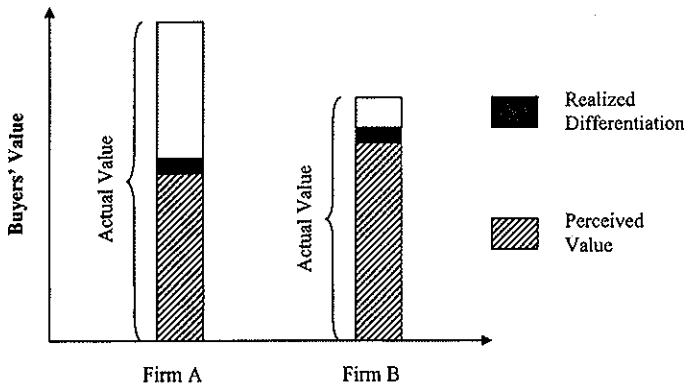
•Vague relationship

It is not YOUR interpretation of quality that matters;
It is the CUSTOMER'S / CLIENT'S

The Value Concept

- The buyer's perception of a firm and its product can be as important as the reality of what the firm offers in determining the effective level of differentiation achieved. Moreover, buyer's incomplete knowledge of what is valuable to them can become an opportunity for differentiation strategy, since a firm may be able to adopt a new form of differentiation preemptively and educate buyers to value it. (Porter, 1985) (Figure 1)

Fig 1 – Signaling Value



More [abstract] Value Concepts… Four Kinds of Value

- Use value
  - Value received from the delivered function. Usually represents properties that accomplish a use, work or service
- Esteem value
  - Value that encompasses our "emotional" regard for the item which we are purchasing. Usually contains properties that make ownership of an object desirable

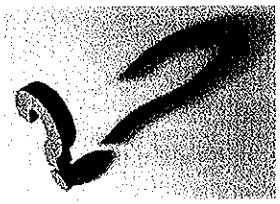
More [abstract] Value Concepts… Four Kinds of Value

- Cost value
  - Amount that we are willing to incur to produce an item. Usually contains properties which are the sum of labor, material, overhead, and other costs required in the production process
  - The cost value of a construction project would be its actual construction cost.
- Exchange value
  - Amount that we are willing to accept in trade for an item. Sometimes this is expressed in monetary terms, or it is a defined product or a certain quality that is acceptable in trade for other items

More [abstract] Value Concepts… Four Kinds of Value

- What kinds of value do we consider in value engineering?



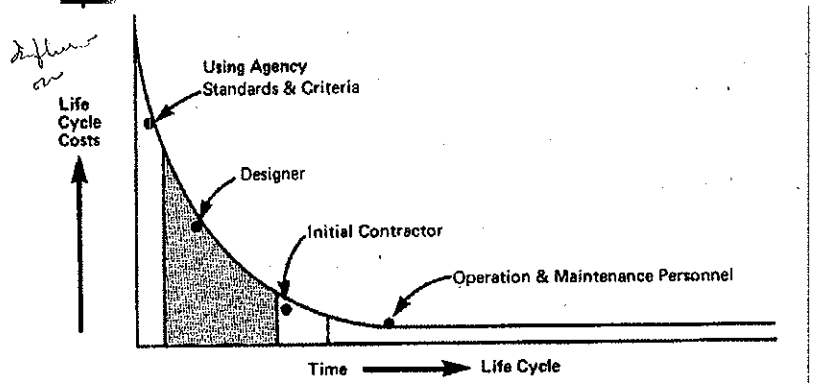


The Cost Concept

- Points to ponder:
  - Who are the players? How do their actions affect costs?
  - Where does the owner's money go during the time period of designing, constructing, maintaining and operating the facility?
  - What potential flaw exists, from VE point of view, in the traditional planning and design approach?



Fig 2 - Major Decision Makers on Facility Costs

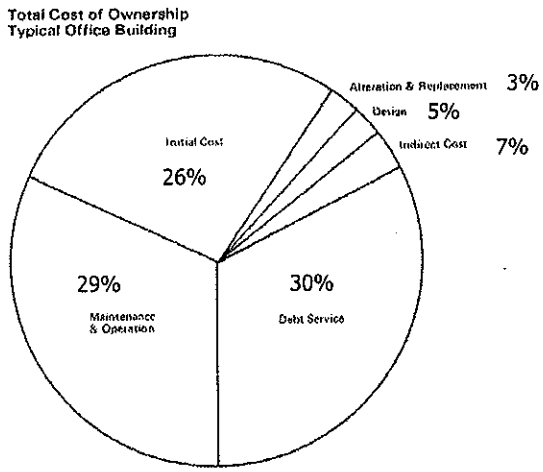


* Persons with impact on total costs.

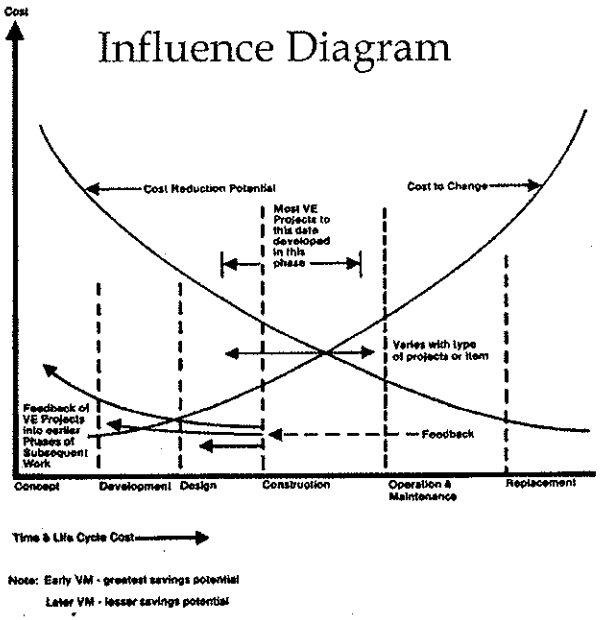
The Cost Concept

- One of the major focal points of VE is **total cost**. How do we define total cost?
  - The sum of all efforts and expenditures made in the development, production, and application of the product (from manufacturing point of view)
  - Life-cycle Costs (more relevant to construction)

Fig 3 – Components of Life Cycle Costs



Influence Diagram



Why all designs would have unnecessary costs

- Lack of Time
  - Every architect / engineer / designer has a due date to deliver his plans. There is only a limited amount of time to make every possible cost comparison in order to achieve the most desirable degree of value
- Lack of Information
  - Insufficient data on the functions of the owner/user wants or needs.
  - Insufficient knowledge on new materials, products, or processes that can meet these needs and are within the required cost range

Why all designs would have unnecessary costs

- Lack of Ideas
  - Failure to develop alternate solutions.
  - In many cases, decision makers accept one of the first workable solutions that come to mind. This tendency invariably causes unnecessary costs, which can be eliminated by requiring the development of additional alternate ideas and then making choices based on economics and performance

Why all designs would have unnecessary costs

- Temporary circumstances that inadvertently become permanent
  - An urgent delivery, design, or schedule can force decision makers to settle on a temporary solution – thinking that it is alright to get back to it later and "fine-tune" the solution. More often than not, we never have time to get back to it so it becomes a permanent requirement

Why all designs would have unnecessary costs

- Honest wrong beliefs and misconceptions
  - Unnecessary costs are often caused by decisions based on what the decision maker believes to be true, rather than on the real facts. Honest beliefs can impede good ideas that would otherwise lead to a more economical decision or service
- Habits and Attitudes
  - Humans are creatures of habit. A habit is a form of response – doing the same thing, the same way, under the same conditions. Habits are reactions and responses that people have learned to perform automatically, without having to think or decide

Why all designs would have unnecessary costs

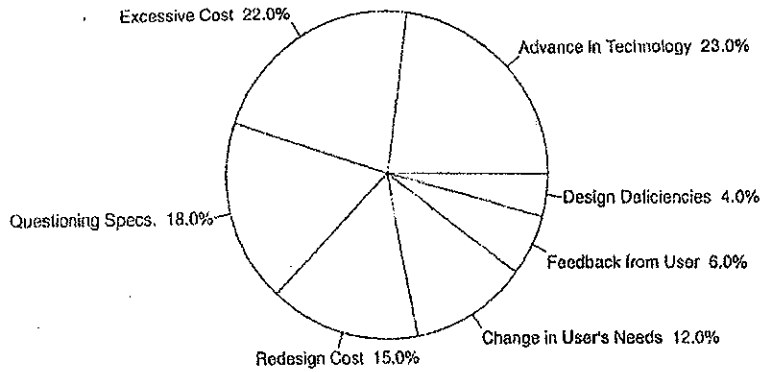
- Changes in owner requirements
  - Often, the owner's new requirements force changes during design or construction that increase costs and alter the schedule. In too many cases the owner is not cognizant of the impact of those desired changes
- Lack of communication and coordination
  - When there is a lack of communication among players, each would attach a different view on the same project components. Even when all of them have the incentives to reduce costs, they would act differently and the cumulative efforts would be less than optimal

Why all designs would have unnecessary costs

- Outdated standards and specifications
  - Many of the standards and specifications in use in large construction programs are at least ten years old. As technology progresses, continual updating of data is required, but it is often not accomplished
- Politics

"If a design/product/system has not changed in years, either it is excellent, or management has failed to improve it."

The Seven ...ost Significant Factors Responsible for Savings Actions



Pareto's Principle applied to Cost Concept

- Commonly known as the "80-20" rule
  - It is often found that there are 20% of the items that make up the bulk (80%) of the costs
- Some "extended" principles:
  - 80% variable costs; 20% fixed costs
  - 80% costs made up by *secondary functions*; 20% by *basic functions*
- Some significant factors responsible for savings actions

Project Selection Criteria

- Probability of significant savings
- Availability of time and resources
- Probability of developing alternates of lower life cycle costs
- Probability of implementation
- Owner's interest

Project Selection Criteria (Younker, 2003)

- Almost any project > US$1 million can afford to have a VE study performed
- Larger and more complex the project => more opportunity for greater return on investment
- E.g. $50 million project; VE team cost is $50,000;
- Initial findings $8 million in *potential* savings → potential return 160:1
- Actual *implemented* savings $4 million, return is 80:1.
- Savings realized on one project multiplied when applied to every other similar project components

Who should constitute the VE team?

- Can constitute the original design team or an external team that are new to the project and who have had no previous involvement in it.
- It may, alternatively, be a mixture of the two, either with or without the presence of the client.
- Specialists may be invited if project has particular problems and specialist input required

Advantages of Using External Team

- Objectivity (note next slide)
- Team can be selected for their particular skills, whereas design team is already established
- Reassurance for the client that design produced by original team is good
- Occasionally good when project has serious political difficulties

Disadvantages of External Team

- Design team may have difficulty accepting presence of external team
- Design team is more "matured" in the project life cycle – having overcome teething problems that groups experience; external team needs time to come together
- External team may not be objective after all; intention to "put on a good show" to impress client; overly critical
- More disruptive than using a design team
- Lack of depth in their understanding of project
- Expensive

Systems Approach to Value Engineering

- Overview of the VE Job Plan
- Information Phase
- Functional Phase
- Creative Phase
- Remaining Phases

[Seven] Phases of the Job Plan

- Information Phase
- Functional Phase
- Creative / Speculative Phase
- Judgment / Judicial Phase
- Development Phase
- Recommendation / Presentation / Proposal Phase
- Implementation Phase

Reasons for Using a Job Plan

- An organized approach
  - Value studies on construction projects could go on for extended periods of time if the studies were not organized and scheduled procedures were not used. Following a job plan allows project studies to accomplish more in a short period of time
- Forces a concise description of purpose
  - The VE Job Plan directs the study team to define the requirements of the project and to assess its true *function*. It utilizes function analysis to delineate the components of the project that are performing the required function and those that are support functions

Reasons for Using a Job Plan

- Zeroes in on high cost areas
  - It allows the VE team to identify the concentration of cost, and to associate cost required to achieve a purpose
- Forces people to think deeper than their normal habit solutions
  - People are accustomed to using the first idea that enters their minds. The job plan directs and motivates people to make several comparisons and to analyze in detail how the total system works, as well as the function of each part

Reasons for Using a Job Plan

- Objective approach
  - The job plan allows an objective look at the project, concentrating on the life-cycle costs of the facility
- Universal approach
  - The job plan is universal in its approach. It has been applied to manufacturing, systems processes, construction projects and software. As long as there is a function required and money spent, the job plan is a good tool to start with

Information Phase

- Purpose is to define the project and provide a database that contains background information on project design, limitations of the project, and sensitivity to costs involved in owning and operating the facility
- Understand the rationale of existing design and validate the assumptions
- Gather as much information as possible
- The longer the length of time since the original design, the more information (regarding development since then) should be gathered

Information Phase

- Caution (1): Intention is not to dispute the work that the design engineer has accomplished. Rather, the approach should be shaped towards collectively identify potential areas of cost cutting
- Caution (2): Know the project constraints (e.g. unalterable owner specifications) – prevent waste of time / embarrassment

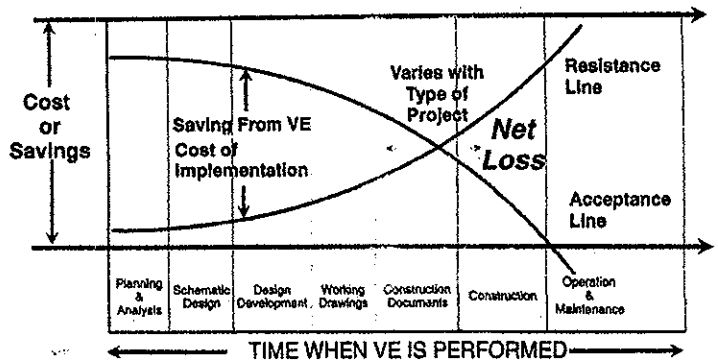
Information Phase

- Some standard information to be obtained:
  - Owner requirements given to architect and engineer
  - Plans and specifications
  - Cost estimates
  - Design data
  - Site conditions (topography, soil condition, aerial photographs)
  - Applicable codes, standards and criteria
  - Maintenance and operations data
  - History of the project

Information Phase

- Conduct site visit
- Gauge the cost of VE study vs. potential savings to be extracted
  - Any repetitive use of design?
  - Give allowance for margin of errors (e.g. estimated savings should at least exceed 3 times the cost of conducting the VE study)

Influence Diagram



Functional Phase

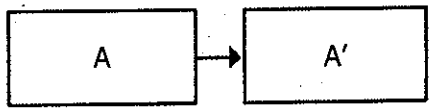
- The purpose of this phase is to identify potential areas of cost savings
- Main tool utilized is Functional Analysis

Functional Analysis

- A cornerstone of VE that separates it from other cost reduction techniques
- Helps to identify what we really want to do and how much we really should pay for doing it
- Involves thinking about **why** an item is necessary, rather than thinking about the item *per se* (i.e. the **what** question)
- It is **function**-oriented rather than **item**-oriented

Function-oriented vs. Item-oriented Cost Reduction

Item-oriented cost reduction involves looking at item A and asking the question -- "How can item A be made at a lower cost?" The result is time A', a modified version of item A, as shown below:



Value Engineering involves looking at item A and asking the questions -- "How can the basic functions of item A be provided at a lower cost?" The result is item B, which is sometimes a completely different item, as shown below:



Advantages of Functional Analysis

- Identifies what owner wants in terms of functions, not things
  - Car example
- Forces conciseness and eliminates fog
- Give room for idea creation
- Creates opportunity for cross-communication

Expressing the Functions – the Verb-Noun Approach

- According to this approach, the function of any item, design, or component is defined literally by **two words**: a verb and a noun
- The *verb* must be an **action** verb and answers the question: "What does it do?"
- The *noun* must be a **measurable** parameter, i.e., frequently can be expressed in units such as kN/m2, Watt, kg, etc

Expressing the Functions – the Verb-Noun Approach

- Some examples of *Work Functions* (with a measurable noun)
  - Support weight
  - Transmit load
  - Enclose space
  - Conduct current
  - Protect people
  - Reduce sound
  - Reduce losses
  - Collect heat
  - Exclude elements

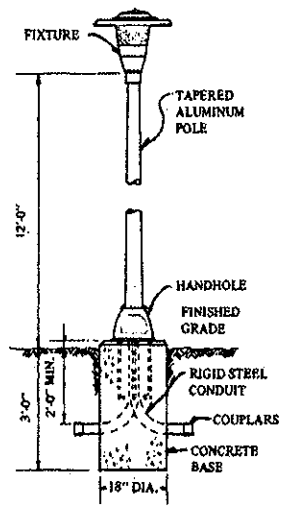
Expressing the Functions – the Verb-Noun Approach

- Some examples of *Sell Functions* (with a non-measurable noun)
  - Provide beauty
  - Beautifies design
  - Improve appearance
  - Enhance service

Classification of Functions

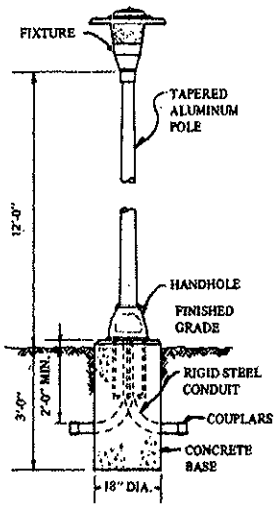
- Basic functions
  - Represent the primary purpose of the design
  - Directly perform the specific work or purpose that the product / project is meant to complete
- Secondary functions
  - These are not required for their own sake – only augment the basic functions
  - May be a necessary part of the project but do not perform the actual work or purpose
  - If the design can be changed, the need for the secondary functions may be modified or even eliminated

Classification of Functions – An Example



POLE MOUNTED LUMINAIRE DIAGRAM

Classification of Functions – An Example



POLE MOUNTED LUMINAIRE DIAGRAM

Parts	Function	Basic	Secondary
Foundation	Support Load Resist Loads Transfer Loads		S
Anchor Bolts	Transfer Load Hold Pole		S
Base	Holds Pole Supports Pole Covers Bolts		S
Pole	Raises Fixture Supports Arm Protects Wire		S
Extension Arm	Holds fixture Spreads Light Protects Wire		S
Housing (Fixture)	Holds Bulb Transfers Electricity Diffuses Light Reflects Light		S
Lightbulb	Produces Light Dissipates Heat	B	

When the scope of the decision is the pole lamp as a whole, the light bulb is the only element delivering the basic function.

Relating Functions to Cost & Worth

- Costs
  - Use estimates from the information phase and distribute among functions identified using cost models (discussed below)
- Worth
  - Defined as the **least** cost required to directly perform the function
  - Most secondary functions are assigned *zero* worth (nonessential)
- Often requires speculation, but precision in estimating worth (and allocating costs) is not critical at this stage
- Determine the Cost-to-Worth ratio (Value Index)
  - Generally if ratio is > 2, it signals possibilities in removing costs within the project

Relating Functions to Cost & Worth – Example 1

FUNCTION ANALYSIS

PROJECT _____ LOCATION _____ CLIENT _____ DATE _____ PAGE _____ OF _____

ITEM - Engineering Management Building; House Personnel; Consolidate Engineering Dept.

FUNCTION:

INFORMATION PHASE

FUNCTION ANALYSIS

ITEM #	DESCRIPTION	FUNCTION VERB	FUNCTION NOUN	KIND	COST	WORTH	COMMENTS
1	Foundation	Support	Bldg.	B	586,249	326,000	
2	Substructure	Support	Bldg.	B	123,550	123,550	
3	Superstructure	Support	Bldg.	B	1,911,411	1,800,000	
4	Exterior Closure	Enclose	Bldg.	B	762,459	620,459	
5	Roofing	Protect	Bldg.	B	101,261	96,200	
6	Interior Construction	Create	Envir.	S	1,186,386	1,160,000	
7	Special Equipment	Assist	People	S	569,815	500,000	Elevators
8	Plumbing	Provide	Sanitation	S	222,816	150,000	Original Cost Looks Low
9	HVAC	Control	Envir.	S	1,325,000	1,200,000	
10	Electrical	Light Power	Bldg. Equip.	B/S	1,358,164	1,287,000	B = 500,000
11	Fire Protection	Protect	People	S	250,000	230,000	
12	Sitework	Provide	Access	S	1,921,000	1,146,000	
13	Electrical Distribution	Service	Bldg.	S	49,500	49,500	
14	Outdoor Lighting	Aids	Security	S	750,000	25,000	
	TOTALS				10,785,869	8,724,233	
	WORTH OF BASIC FUNCTIONS					3,470,000	

ACTION VERB

MEASURABLE NOUN

KIND [B = Basic; S = Secondary

(Basic Function Only) Cost / Worth Ratio = 10,785,869 / 3,470,000 = 3.10

WORKSHEET № 2

Relating Functions to Cost & Worth – Example 2

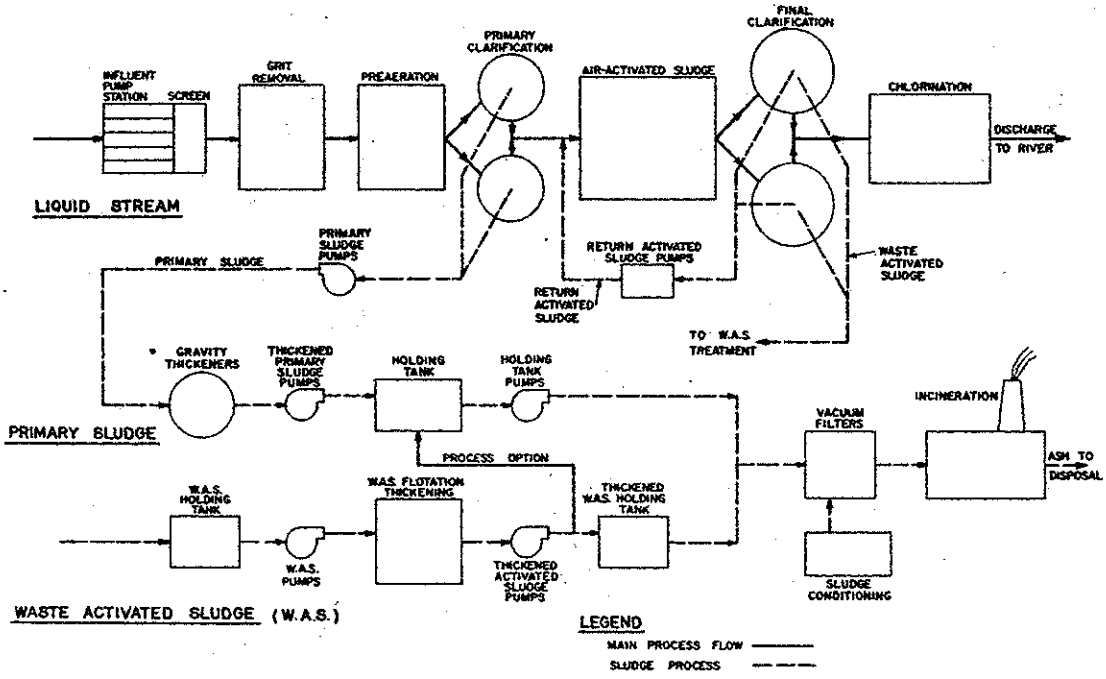
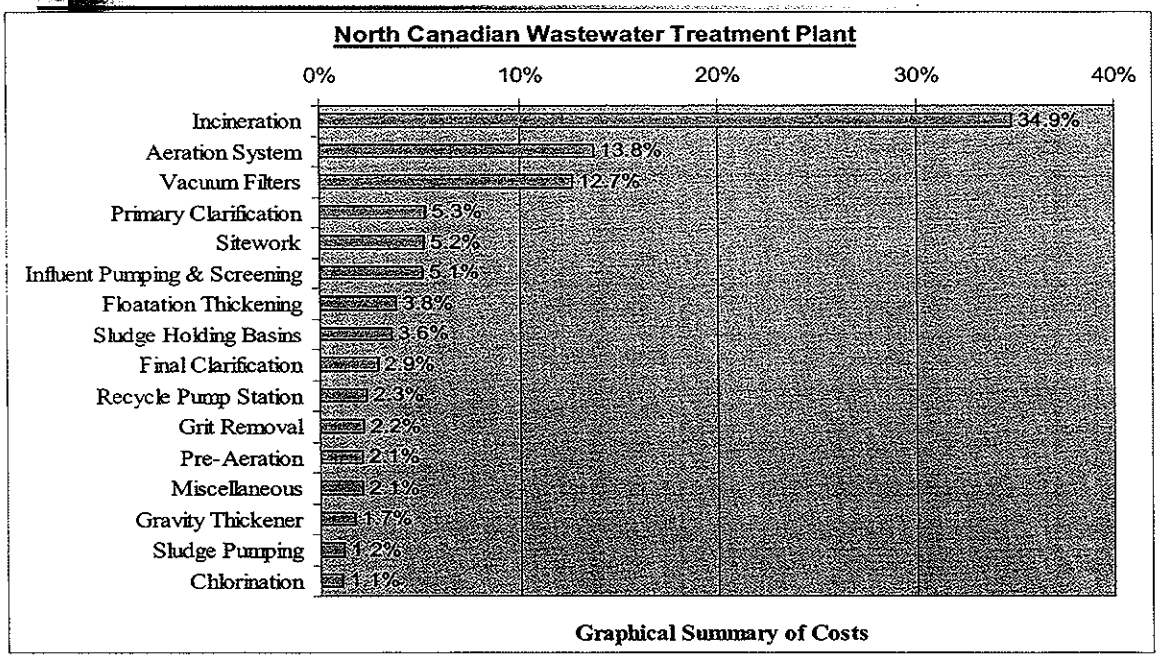


Figure 10-1. Process Flow Diagram--North Canadian Wastewater Treatment Plant.

Relating Functions to Cost & Worth – Example 2



Relating Functions to Cost & Worth – Example 2

FUNCTION ANALYSIS

PROJECT _____ LOCATION _____ CLIENT _____ DATE _____ PAGE _____ OF _____

ITEM #	DESCRIPTION	FUNCTION			COST	WORTH	COMMENTS
		VERB	NOUN	KIND			
	Influent Pump Station	Lifts	Sewage	S			
	Screening	Remove	Trash	S	1,250	1,000	
	Flow Measurement	Measure	Flow	S			
	Grit Removal	Remove	Grit	S	545	50	
	Pre-aeration	Freshen	Sewage	S	520	0	
	Primary Clarifiers	Remove	Solids	B	1,300	750	
	Aeration Basins & Equipment	Remove	BOD	B	3,405	2,000	
	Recycle Pump Station & Secondary Clarifiers	Remove	SoBds	B	1,290	1,000	
	Chlorination Facilities	Disinfect	Effluent	B	260	250	
	Instrumentation	Monitor	Process	S	520	0	
	Site Work	Position	Plant	S	1,275	500	

ACTION VERB
MEASURABLE NOUN

KIND [B = Basic, S = Secondary]

(Basic Function Only)
Cost/Worth Ratio = _____

ITEM : Entire Plant
FUNCTION : Treat Sewage

FUNCTION ANALYSIS

INFORMATION PHASE

65

Relating Functions to Cost & Worth – Example 2

FUNCTION ANALYSIS

PROJECT _____ LOCATION _____ CLIENT _____ DATE _____ PAGE _____ OF _____

ITEM #	DESCRIPTION	FUNCTION			COST	WORTH	COMMENTS
		VERB	NOUN	KIND			
	Primary Sludge Pumping Station	Pump	Sludge	S	337	225	
	Activated Sludge Holding & Pumping	Pump	Sludge	S	430	250	
	Flotation Thickening	Thicken	Sludge	S	940	500	
	Gravity Thickeners	Thicken	Sludge	S	420	0	
	Mixed Sludge Holding	Blend	Sludge	S	400	0	
	Vacuum Filtration	Dewater	Sludge	S	3,130	750	
	Incineration	Reduce	Volume	S	8,600	750	
					24,622	8,025	$\frac{\text{COST}}{\text{WORTH}} = 3.07$
							$\frac{\text{COST}}{\text{WORTH (BASIC)}} = 25.57$

ACTION VERB
MEASURABLE NOUN

KIND [B = Basic, S = Secondary]

(Basic Function Only)
Cost/Worth Ratio = _____

ITEM : Entire Plant
FUNCTION : Treat Sewage

FUNCTION ANALYSIS

INFORMATION PHASE

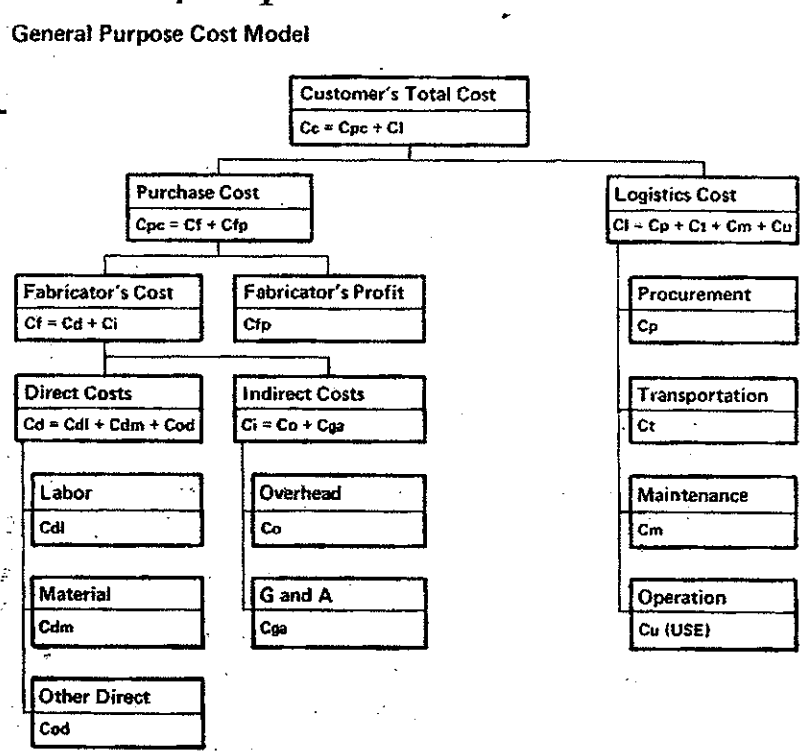
WORKSHEET № 2

66

Some Common Types of Cost Models

- General-purpose cost model
  - For simple, straightforward projects or components

General-purpose Cost Model

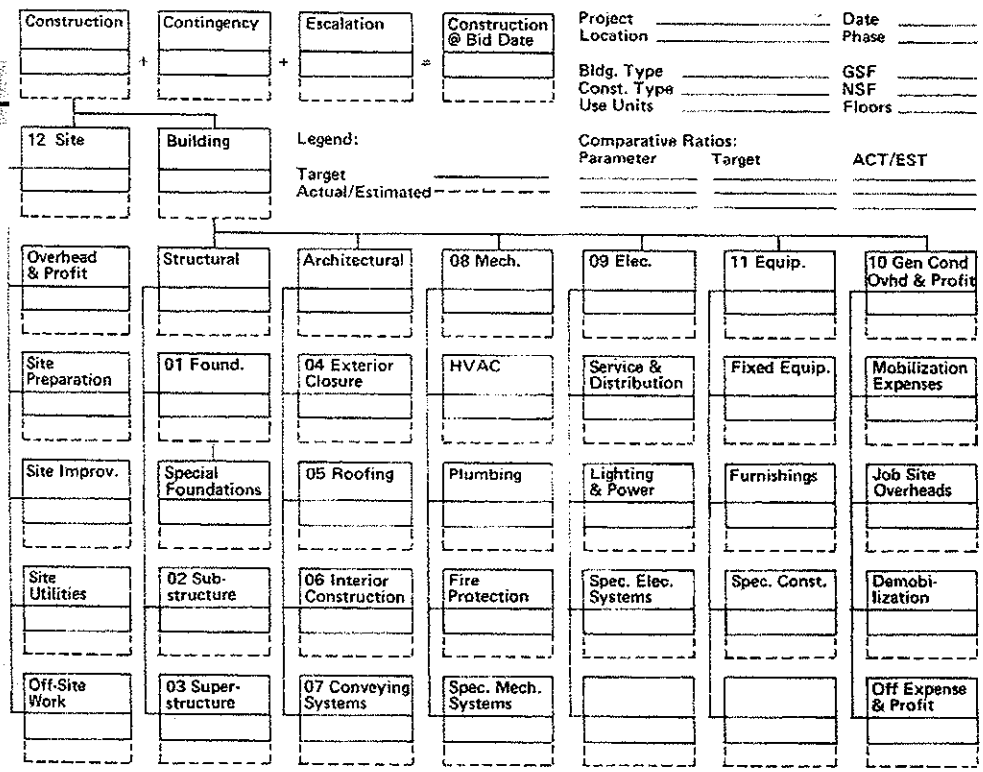


Formula: $C_c = \{[(C_{dl} + C_{dm} + C_{od}) + (C_o + C_{ga})] + C_{fp}\} + (C_p + C_t + C_m + C_u)$

Some Common Types of Cost Models

- The Uniformat system
  - System-oriented
    (divides project into systems and subsystems)
  - Has greater application for the designers
  - Preferred format for VE studies during **early design**

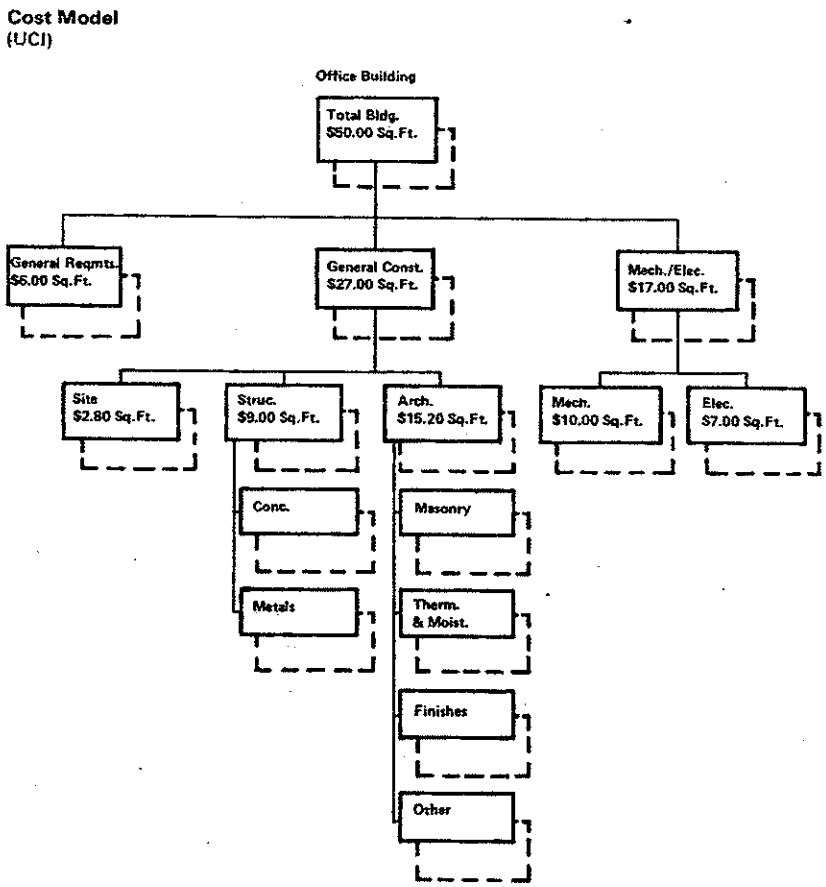
The Uniformat System



Some Common Types of Cost Models

- The Masterformat system
  - Trade-oriented
  - Costs are broken down by trades such as concrete, metals, masonry, finishes etc.
  - Adopted by most contractors
  - Suitable as the project is moving towards the **bidding phase**

The Masterformat System



Some Common Types of Cost Models

- Cost Matrix
  - Separates the construction trade components of projects and also distributes these into various elements and systems of the projects

Cost Matrix

COST MATRIX FOR WASTEWATER TREATMENT PLANT

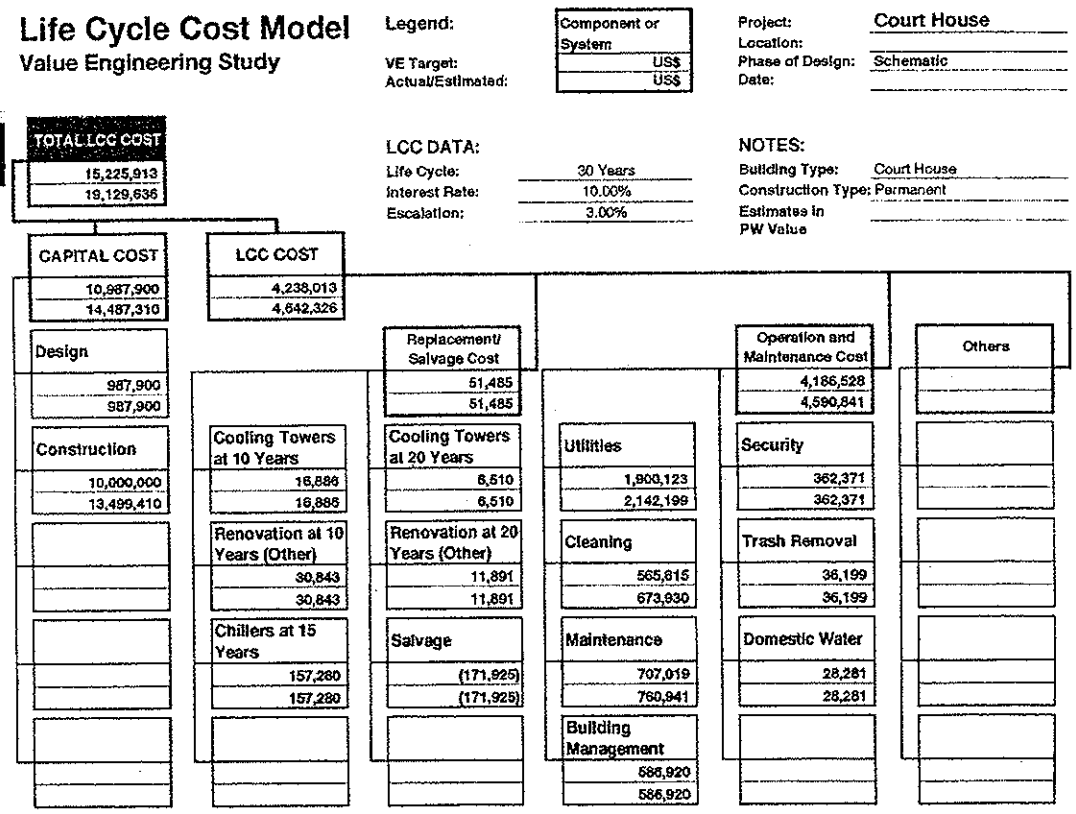
Item No.	Description	Liquid System					Solios System		Support System			Percent	Totals
		Influent Facilities	Primary Clarifier & Pump Sta.	R.B.C.'s	Final Clarifier & Pump Sta.	Effluent Pump Sta. & Chem. Storage	Sludge Processing Bldg	Thickener	Tunnel	Control Bldg	Site Work		
1	Major Equipment	150,000	194,400	1,142,000	176,500	617,900	841,400	198,000	-0-	37,500	-0-	30.7	3,367,700
2	Concrete	92,500	349,500	337,500	378,750	184,000	179,000	125,000	117,050	90,200	-0-	16.9	1,853,500
3	Site Work	2,000	259,500	119,500	311,500	65,000	43,000	39,500	-0-	4,000	826,000	15.2	1,670,000
4	Piling; 60 Ton	36,000	146,700	234,000	144,000	139,300	117,900	95,400	32,400	84,600	15,300	9.5	1,045,600
5	Architectural	12,000	-0-	-0-	-0-	278,500	185,000	-0-	-0-	328,800	-0-	7.3	804,300
6	Electrical	3,000	45,000	90,000	45,000	270,000	35,000	35,000	10,000	60,000	20,000	5.6	613,000
7	Inside Piping	35,000	75,600	-0-	50,300	180,000	30,200	41,300	41,200	-0-	-0-	4.1	453,600
8	Outside Piping	-0-	34,600	-0-	55,000	-0-	-0-	-0-	-0-	-0-	287,500	3.4	377,100
9	Instrumentation	10,000	15,000	10,000	15,000	60,000	40,000	10,000	-0-	140,000	-0-	2.7	300,000
10	Misc. Equipment	60,000	10,500	75,000	37,000	-0-	15,000	-0-	-0-	20,000	-0-	2.0	217,500
11	HVAC	5,000	2,600	2,600	2,600	15,000	60,000	2,600	2,600	112,000	-0-	1.9	205,000
12	Plumbing	1,000	2,000	2,000	2,000	2,000	12,000	2,000	1,000	36,000	-0-	0.7	60,000
	COST	406,500	1,135,400	2,012,600	1,217,650	1,841,700	1,558,500	548,800	204,500	913,100	1,148,800	100.0	10,987,300
	PERCENT	3.6	10.3	18.3	11.1	16.8	14.2	5.0	1.9	8.3	10.5		
		60.1					19.2		20.7				
									Contingencies 20%				2,197,700
									Total				13,185,000

Taken from a study conducted by Arthur Beard Engineers, Inc and Greeley and Hansen.

Some Common Types of Cost Models

- Life Cycle Cost (LCC) Model
  - Ultimate indicator of value to the client: encompasses both initial costs and running costs and takes into account all probable costs over the life of the facility
  - Can be based on either annualized cost or present worth approach
  - Worth for annual expenditures such as maintenance, alteration, replacement, security etc. can be judged from historical data and those published by institutions
  - Worth for the facility cost can be taken from one of the previous cost models

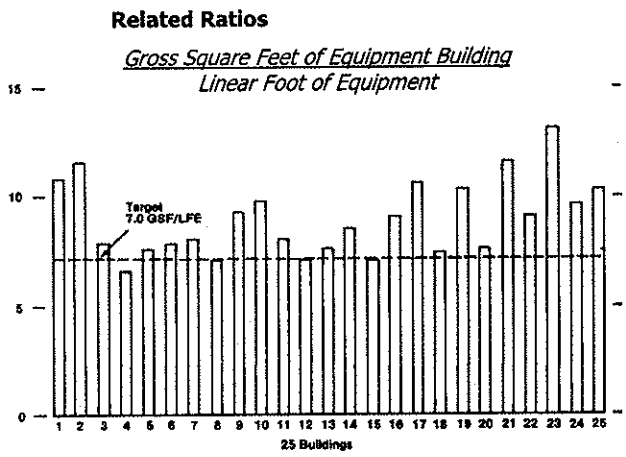
Life Cycle Cost Model



Other Techniques related to Functional Analysis - Benchmarking

- Ratios as rough gauge of costs against certain benchmarks
  - Gross square meter per basic building parameter (e.g. occupant, bed, etc.)
  - Net usable area per gross floor area
  - Cost per kW of incoming power
  - Cost per square meter of exterior wall
  - Cost per kN/m2 of live load
  - Cost per ton (HVAC)
  - kW hr / square meter / year (for energy)

Benchmarking - Example

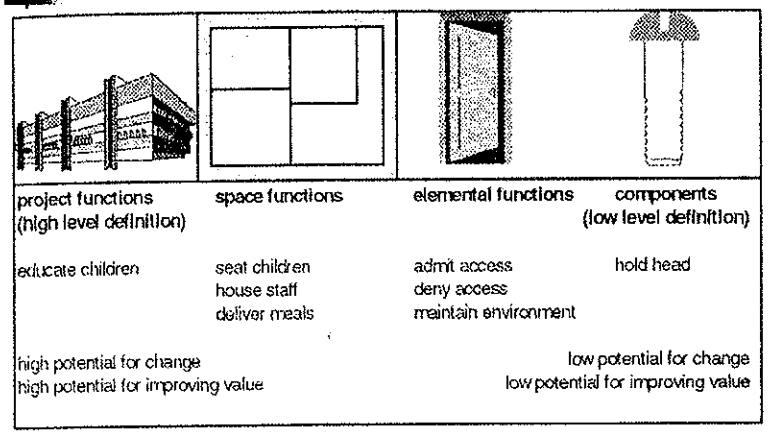


Related Ratio Graph - Gross SF/LF of Equipment

At this point .....

- Note that often times functional analysis can be applied in stages, zooming in from
  Project -> Spaces -> Elements -> Components
- Project: function of a bridge? Or a school?
- Spaces: Classrooms, staffrooms?
- Elements: Doors with security system?
- Components: Sills, heads, jambs of a window?

Levels of functional analysis



At this point .....

- Alternatively it may also be helpful to think in terms of various *Systems*
  - Product Systems
  - Production/Construction Systems
  - Management Systems
  - Service Systems

Creativity Phase - Background

- Creativity refers to behavior that uncovers a relationship where none previously existed; a relationship between people, objects, symbols, or any combination of these.
- There are many levels of creativity, ranging from discovering something that is new to oneself, to discovering something new to someone else, to patenting an invention.

Creativity - Background

- Some creative people
  - Children
  - Scientists
  - Pioneers
  - Seabees (part of U.S. military)
  - Writers
  - Housewives
  - Architects & engineers
- ➢ Think of a reason for each of the above why these people can be creative

Types of Mental Processes

- Noncreative mental processes
  - Remembering – recall all past experiences and previously acquired ideas
  - Reflection – total review of the content of mind
  - Reflection – study of surrounding objects and circumstances
  - Association – comparison of the present problem parts with the solutions to previous problems
  - ➢ *Important limitation: logical thought is incapable of originating something that is entirely new*

Types of Mental Processes

- Creative mental processes
  - *Imagination* enables us to blend ideas into new combinations while we are engaged in *deliberate thinking*. Usually deals with common and easily remembered ideas
  - *Inspiration* is the result of *accidental stimulation*. Occurs when new ideas are triggered by some object, circumstance, or comment which suddenly and spontaneously fits together with old ideas
  - *Illumination* is a blend of *Imagination* & *Inspiration*

Some Theoretical Evidence

- Left and Right Brain Theory
  - Left half used to analyze and solve problems in a step-by-step manner
  - Left half also controls verbal skills
  - Right hemisphere is the creative side devoted to problem finding, esthetic judgment and intuition
  - Right half processes information that cannot be put into words, and thinks in terms of whole patterns even when only partial information is available

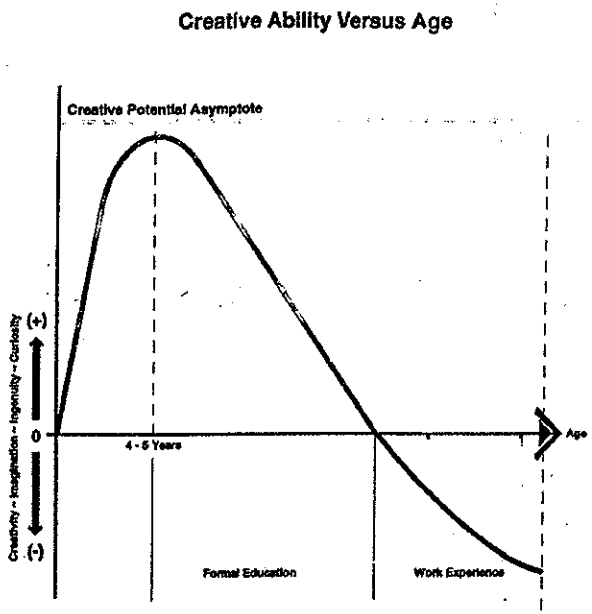
Some Theoretical Evidence

- There is evidence that differences in cultures between East and West can be traced to different way of using the brain

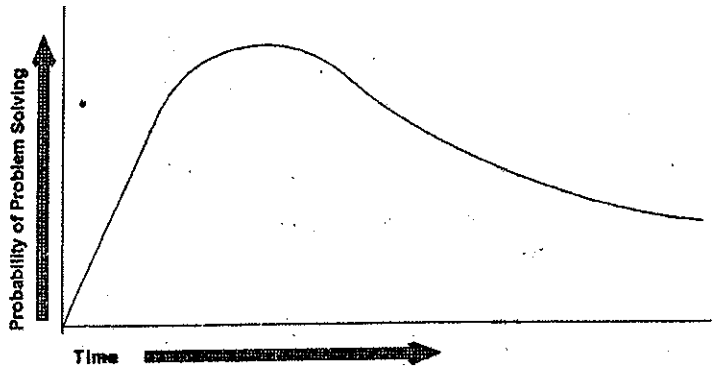
  ---- (Dr. Tadanobu Tsunoda of Tokyo Medical Dental U)
- Engineers - left brain or logic and reason oriented
- Architects - right brain oriented or devoted to creativity, aesthetic judgment, problem finding
- When working together, although their background may complement each other, they look at things differently and may have difficulty understanding each other's viewpoints

Creativity and Fixation

- The creativity process starts early in life for every individual and maximizes at 4 or 5 years of age.
- From then on, "constraints" & "rules" are added .....



Creativity and Fixation



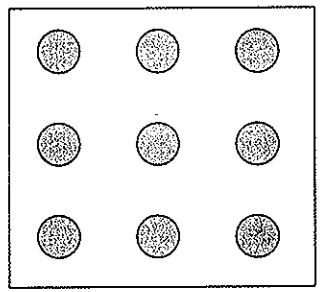
Creativity and Fixation

- When one addresses a problem, if a solution is not uncovered within a short period, *fixation* may occur
  - Basic solutions come early – the longer the time, the less the probability
  - Based on established patterns, fixation sets limits on creative thinking
  - Unless overcome, fixation stimulates mediocrity
  - It can force the use of traditional approaches over more creative ones
- Let's try some exercises to see how creative or "fixated" you are……

The Nine-Dot Puzzle

(Source: Conceptual Blockbusting: A Guide to Better Ideas by James L. Adams)

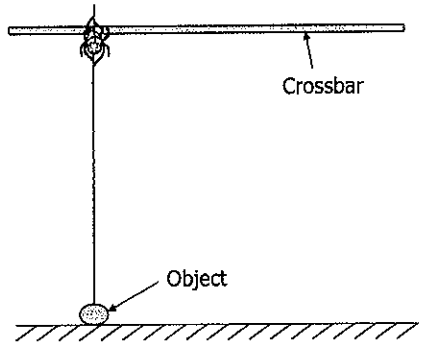
- Draw out nine dots with the following layout; without lifting your pencil, draw Four/Three/One straight line(s) that cross all nine dots.



Learning from the Nature

(Source: Building Construction Before Mechanization by John Fitchen, 1996; MIT Press)

- A spider needs to lift an object from the floor (see picture). It may spun strands onto the object, but unfortunately the object weighs over twenty times of its weight – so the spider would have insufficient strength to lift it up directly.

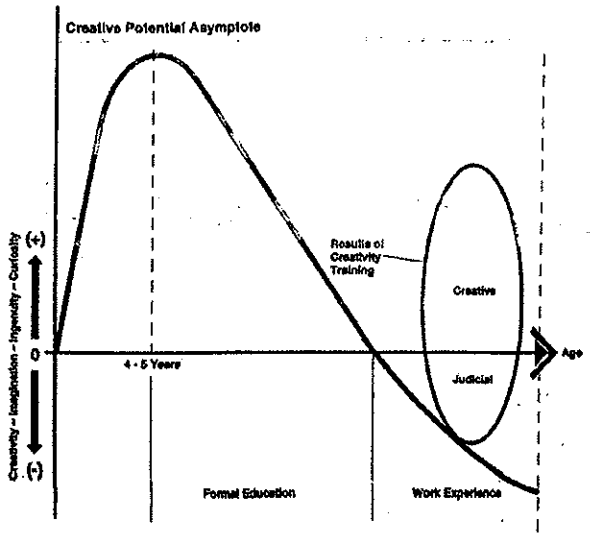


- If you were the spider, what would you do?

Creativity and Fixation

- Creative techniques are exercises to help one overcome fixation. **With training and deliberate practice, creativity can be regenerated.**
- One important aspect of training – overcome emotional block such as fear of making a mistake or appearing foolish
- Because of the team element in the creative process, the rate at which you become creative can depend in large measure on your interpersonal skills.

Creative Ability Versus Age



Creativity and Value Engineering

- In VE, creativity plays an important part in a project. The VE analyst is asked to develop new ideas that go beyond the original concept of the designer.
- All ideas need not be considered individually. Consider combining different ideas.

Creativity and Value Engineering

- The architect and project engineer exercise creativity by formulating a combination of materials, system processes and techniques to accomplish a required function
- The VE team, on the other hand, begins with the designer's proposal and develops new ideas, combination and techniques that go beyond the architect's and designer's normal design techniques
- A specific period of time on each project is allotted to VE to encourage the creation of new problem solving techniques

Selecting Team Members for Creative VE Session

- When staffing a value engineering study, we look for creative individuals. It then becomes important to know the characteristics of creative people in order to select the best team members for a VE team.
- The prime theses behind creativity is that the individual believe that it can be done

Characteristics representative of Creative People

- Motivation
  - Desire to find a better solution for the project. People who are highly motivated will push themselves and the members of their team to go beyond their normal habits in seeking solutions
- Flexibility in thinking
  - Many of the best recommendations come from people outside their particular field of study. A person must be open to change and be flexible to reorient his thinking process with new and more effective information

Characteristics representative of Creative People

- Originality
  - The original thinker is an inquisitive individual who is unwilling to accept the statement, "we have always done it this way – so why change?" as a logical solution.
- Sensitivity to the problem
  - Experience in VE on construction projects has shown that certain people can zero-in on the high cost areas of a project in a short time. They have a perception and a feel for the cost being paid for the required function

Characteristics representative of Creative People

- Ability to abstract
  - In engineering, very little abstract thinking goes to the design. They are primarily based on material properties, proven strength and scientific knowledge. Developing new ideas that are yet unproven is not something that an engineer is used to doing.
- Tolerance of ambiguity
  - In VE studies, we are often unsure whether our creative ideas will in fact be developed and eventually recommended. There is always some ambiguity in coming up with a creative idea.
- Greed (huh??)

Some Ground Rules in Conducting a Creative Session

- Overcome inertia toward change and toward the unconventional
- It helps to have crazy ideas – remember, all truly great ideas seem absurd when first proposed
- Develop as many ideas as possible, and record all these ideas

Some Ground Rules in Conducting a Creative Session

- Judgment is a factor that affects the acceptance or rejection of creative ideas. Often, people with high intelligence will attempt to block an idea with little consideration of facts. It is important that the leader gently but firmly ensure that **judgment is suspended during the session** and defer till the next phase.

Some Common Creative Problem Solving Techniques - Brainstorming

- A group of individuals of different disciplines in a construction project are brought together in a group. The group is lead by one individual.
- Prior to the session, the team is briefed on the design project and on requirements of the owner and limitations that are imposed.
- The brainstorming session is started by having each individual first list his creative ideas for the problem. After that the team is asked to come together as a whole and work as a group in determining creative solutions to the problem. External evaluation by team members must be absent.

Some Common Creative Problem Solving Techniques – Gordon Technique

- This is also a group-creative technique
- In many ways it is the direct opposite of the brainstorming technique.
- The group meets without any prior knowledge of the problem or project being studied. The leader of the session guides the team into broad areas in which the problem might be identified

Some Common Creative Problem Solving Techniques – Checklists

- Past history and precedents on prior studies may have resulted in an accumulation of ideas that resulted in savings to the owner
- This list of ideas serves as a basis for comparison on new studies. It would thus be helpful to check back on past projects to see if there are any ideas that continuously occur

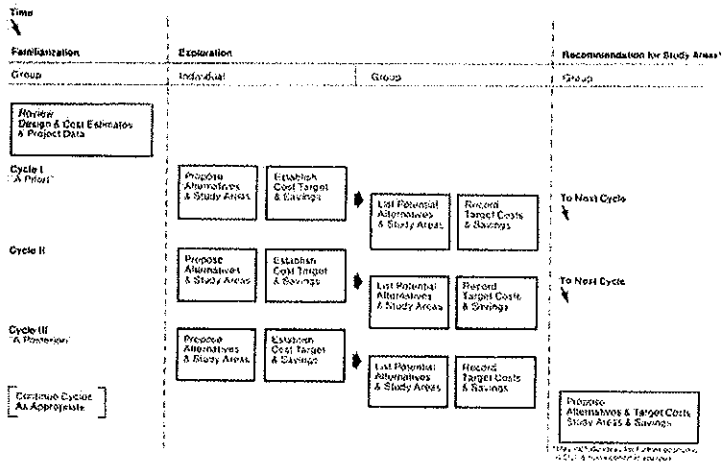
Delphi Techniques

- Developed by the Rand Corporation in the early 1950s (www.rand.org)
- May be used for:
  - Selecting and evaluating project areas for study
  - Putting together a (conceptual) cost or energy model
  - Identifying the pros and cons associated with potential design options
- Some characteristics of Delphi:
  - It is an exercise involving a group
  - The goal of the exercise is cost and design information
  - Information to be sought is uncertain in the minds of the group

Delphi Techniques

- A systematic procedure is followed in obtaining the group output
- Methodology (see figure)
- Cycles of familiarization -> exploration -> recommendation
- Individual -> Group -> Conference

Delphi Techniques



Delphi Techniques

- Main advantage of Delphi:
  - It minimizes the bias of personality in obtaining a single group opinion by fostering constructive cooperation among participants who will commit not to disagree and to explore further
- Delphi is particularly effective in the following situations:
  - Short VE studies of 1 to 3 days
  - Studies made up of team members with no prior VE experience, e.g., client
  - Studies in which participants are higher-ranked staff not inclined to learn the "nitty-gritty" about VE

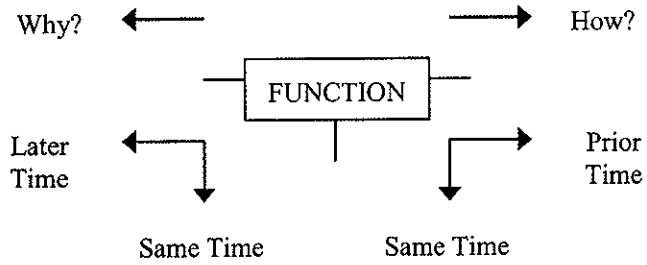
Functional Analysis System Techniques (FAST)

- Introduced by Charles Bytheway in a paper delivered at the 1965 National Meeting of SAVE
- A useful communication tool that simplifies and improves identification of the basic functions of item being value analyzed
- Assists in providing a basic understanding of the project and isolating high cost functional areas

Functional Analysis System Techniques (FAST)

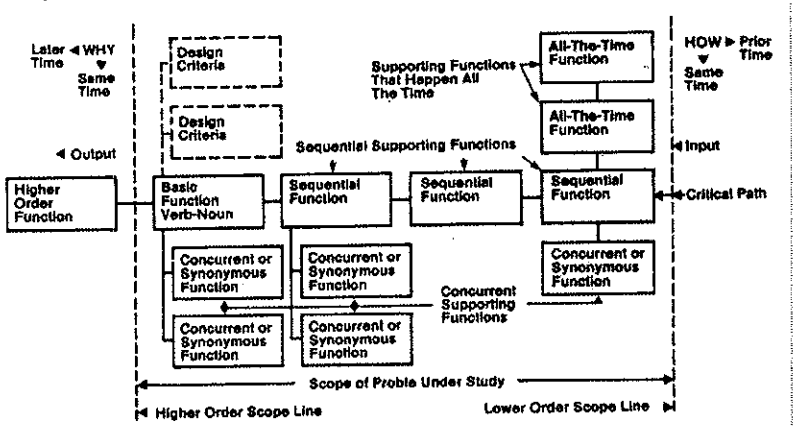
- FAST involves a function block diagram based on answers to Why, How & When questions:
  - Answers to the question "Why?" leads to higher level functions, conventionally placed on the left
  - Answer to the question "How?" identifies lower level functions, conventionally placed on the right
  - The question "When?" may also be asked of each function, and is diagrammed in time sequence in relation to other functions. Examination of the diagram vertically illuminates the matter of which functions are to be accomplished at the same time and the sequential relationships of others

Functional Analysis System Techniques (FAST)

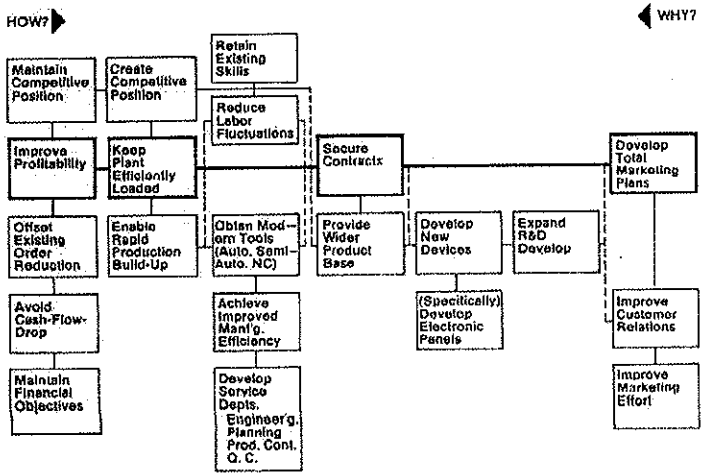


- The result is a hierarchy of functions showing logical Why/How/When relationships

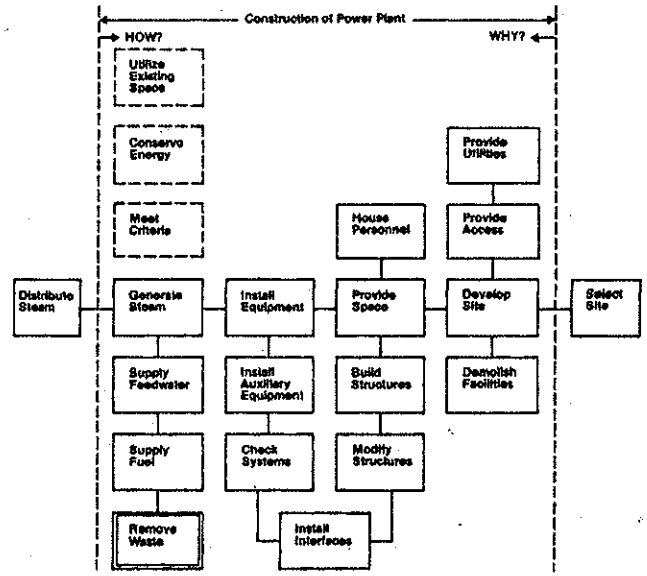
FAST Diagram Procedures



FAST Example: Long Range Plan for a Company



Construction of a Power Plant



Functional Analysis System Techniques (FAST) - Issues

- FAST is a systematic roadmapping of functions
- Provides an organized method of exploring complicated processes or assemblies and determines in a step by step method the function required and a means to arrive at that function
- Note that FAST overlaps with both Functional and Creative phases. Its implementation can thus occur either current to or after functional analysis.

Judgmental/Judicial Phase

- Screening, filtering ideas - listing advantages & disadvantages of each
- Setting up criteria for screening - some examples:
  - Meet functional requirements?
  - Impact on design and construction schedule?
  - Any track record of performance on new proposed design?
  - Does the idea materially affect the aesthetics of the building/project?
- Ideas evaluated and ranked
- Evaluation of ideas should be as objective as possible

Development Phase

- During this phase, the most feasible options are examined closely to confirm if:
  - All design and operating specifications are met
  - Standard practices and materials are [can be] used
  - Costs to implement, redesign, remove and modify existing facilities are computed
  - Collateral benefits and costs are considered
- Effectively takes ideas remaining after the Judgment Phase and further develops them into workable solutions
  - Ideas more thoroughly researched
  - Preliminary designs and sketches prepared
  - Life cycle cost estimated (later)

Development Phase

- Use company and industry standards wherever feasible
  - No developmental costs required
  - Good quality and reliability is reasonably ensured through past revamp and correction of defects
  - Performance characteristics are more readily ascertainable
- Consult external vendors and specialists if necessary
- Be aware of the impact on other areas and necessary approvals from other parties for the new design to work
- Check on other aspects: quality, performance, safety
- Look out for unusual requirements such as special labor or materials, risks, safety issues

Development Phase

- This is the phase where the technical expertise of team participants obviously come into play
- Usually need to return to previous phases to collect more info
  - VE is an iterative process
- Identify factors for ratings and assessment of performance, aesthetics, reliability, life-cycle costs, etc.
- Rate each alternative by entering ratings for each factor and multiplying by the weight of the factor
- Conduct sensitivity on weights/ratings

Presentation/Recommendation Phase

- Information must be summarized in a clear, concise manner and each idea documented
- Summarize costs in $ and % terms
- Salesmanship
  - *What related concept should you recall?*
- Practical issues:
  - Always keep track of the tradeoff between cost savings and delay from implementing new design when idea is finally accepted
  - Constantly update the designer as VE progresses to eliminate surprises

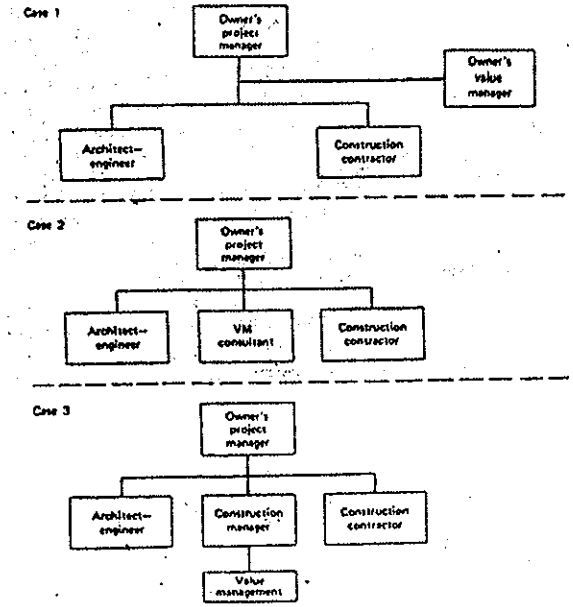
Presentation/Recommendation Phase

- A complete report should include
  - Brief description of project vs. Brief summary of problem and recommendations
  - Results of functional analysis
  - Sketches of the "before" and "after" designs
  - Technical data supporting your selection of alternates
  - Cost analysis comparing before and after designs
  - Summary statement listing justification for selected solution, and actions required for implementation

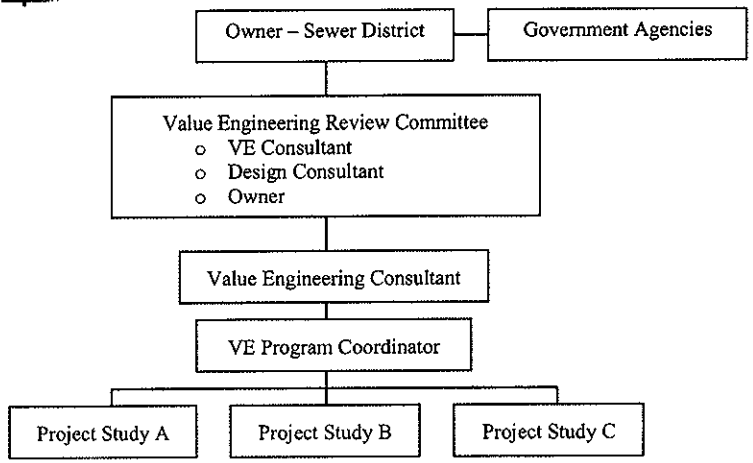
Implementation Phase

- Organizational design (see figure)
- Cost, time and manpower allocation for study and follow-up
- Authority & power to follow through
  - Every project should have a champion
- Incentive issues (internal vs. external)
- Explore potential commercial value in the developed VE solutions

Org. Setting for VE Study



Organizational Setting for VE Study

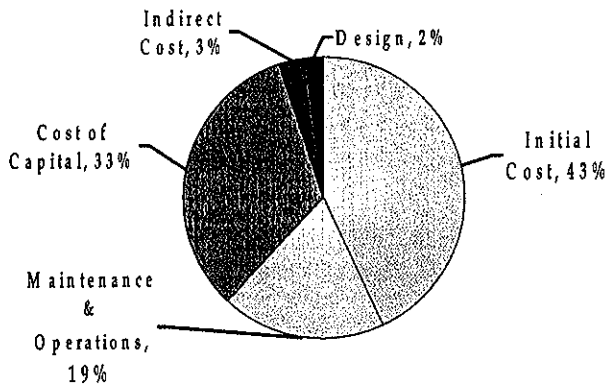


A Synopsis of Life-cycle Costing & Cost Modeling

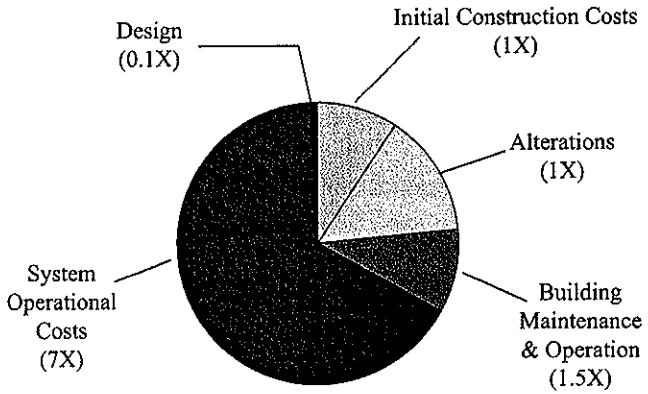
Definitions of Life-Cycle Costs

- The total cost of an asset over its operating life, including the initial acquisition costs and subsequent running costs
- An economic assessment of an item, area, system or facility considering all the significant costs of ownership over an economic life, expressed in present value terms

Total Cost of Ownership – "Typical" Office Building



Hospital Life-cycle Costs (20 years)



Life-cycle Costing & Value Engineering

- All VE studies should be done on the basis of life-cycle costs
  - One proposed design has high initial construction cost because it specifies more durable building systems that minimize future ownership costs
  - Another has a low construction cost by specifying less costly building systems that will require large future expenditures for maintenance, repair, operation, alterations, and utilities
    - *Which design is better?*

Life-cycle Costing & Value Engineering

- Cost is the most objective (though not necessary the ultimate) measure for comparison of ideas – a common denominator
- Analysis often expands to consider non-economic factors such as safety, environmental goals, aesthetics, flexibility, politics etc – although all these are harder to quantify

Elements of Life-cycle Costs

- Investment costs (similar to "start-up" costs)
  - The amount of money expended for assessment of market potential, for time and expenses involved in analyzing site alternatives and expenses incurred for development of a financial plan
  - Investment costs may also include expenses for obtaining a line of credit and other financing alternatives
  - Preparation of stock and bond sales may be another type of investment cost

Elements of Life-cycle Costs

- Land acquisition costs
  - Costs for realty fees, title searches, legal fees, deed filing fees, insurances, cost of land and the interest on borrowed money for the purchase or leasing of land for use of a facility
- Engineering costs
  - Costs associated with the planning, design, bidding, construction, inspection and initial start-up of the facility
  - Any anticipated future costs for design modifications should also be included

Elements of Life-cycle Costs

- Redesign costs
  - The cost of modifications to the original plans and specifications to accommodate value engineering changes
  - Often included in the redesign costs are any costs from delay in completion of the project directly attributed to making VE modifications
- Construction costs
  - The cost of constructing the building or facility

Elements of Life-cycle Costs

- Administrative fees
  - Generally the cost of managing and coordinating the project
  - Included are the owner and administrative staff that do the planning, contracting, personnel recruitment, staffing, marketing and the legal costs associated with the project

Elements of Life-cycle Costs

- Replacement costs
  - Future costs to modify or replace a portion of the project. Usually equipment is the major source of replacement costs
  - Based on the expected life of the equipment, several replacements may occur during the total project life
  - Painting and other maintenance requirements may also fall under this category
- Salvage value
  - The value of the project or product at some future time. Usually salvage value is the amount received from the sale at the end of the life-cycle period

Elements of Life-cycle Costs

- Operating & maintenance costs
  - Costs required to operate the facility. These costs are often periodic costs falling at scheduled intervals
  - Day-to-day costs of staffing
  - Energy costs to create and maintain a working environment and to operate equipment
  - Costs of outside services such as waste disposal, water and sewage costs
  - Chemicals and other resources needed to manufacture or to process a product
  - Costs of transportation from the source of raw materials to the final delivery point

Elements of Life-cycle Costs

- Financing costs (cost of capital)
  - Fund solicited for development, operation and maintenance of a project actually comes with a price tag attached
  - For the amount of money loaned (debt), the financing cost is obviously the interest payments
  - When owner finances the project with its own capital (known as 'equity'), there is an opportunity cost to the use of this capital
  - The combined cost of both debt and equity is usually known as the "weighted average cost of capital" (WACC)

Life-cycle Costing & Value Engineering

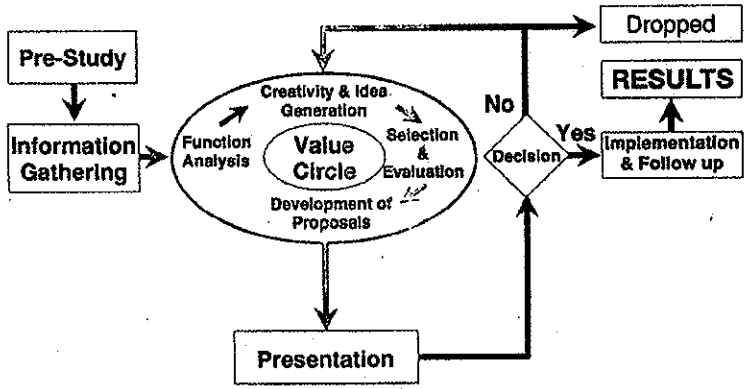
- Five principal stages in LCC evaluation
  - Identify owner's criteria
  - Forecast economic parameters
  - Identify initial and running costs
  - Obtain suitable cost estimates and life cycles of project elements
  - Rank alternatives using proper evaluation methods

Evaluation Issues and Cost Modeling

- Discount Rates / Opportunity Cost of Capital
  - The expected rate of return demanded by investors in common stocks or other securities subject to the same risks as the project
- Inflation & Escalation
  - Nominal vs. Real cash flow and interest rates
- Others: taxes, depreciation, lease vs. buy
- *Most of these issues are covered in detail in capital budgeting or a corporate finance course. Life-cycle costing only applies selected principles from this much richer context*

Summary

Value Engineering Job Plan

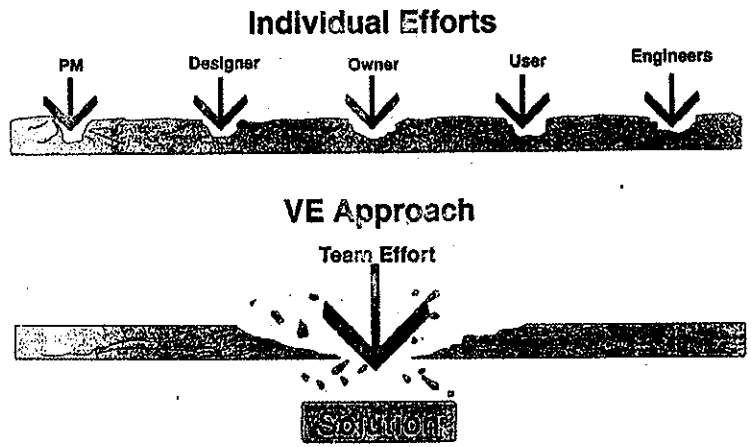


Summary

Relationship of Current Activities with VE and Other Techniques

Supporting Activities Useful as Information Sources	VE Methodology	Supporting Techniques for Redesign, Development Work and Selection of Alternatives	Results
•Audits •Management Surveys •Management Improvement •Management by Objectives •Zero-based Budgeting •Employee Suggestions •Energy Program •Performance Indicators •Contractor Ideas •Paperwork Management •Productivity Measurement •Complaints	Function Analysis (Cost) vs. (Worth) Function Analysis System Technique (FAST) Diagramming	•Work Simplification •Economic Analysis •Life Cycle Costs •Design-to-cost •Management Analysis •Flow Charting •Weighted Evaluation •Trade-off Analysis •Systems Analysis •Cost Reduction •Risk Assessments •Total Quality Management	Optimize Value Cost Savings Time Savings Manpower Savings

Summary - Conventional Approach vs. VE Approach



Advantages of Value Engineering

- More project worth; less costs
- Higher quality projects result
- Earlier completion of projects
- Fewer problems and disputes will occur
- Improved reputation and safety for the projects
- Happier employees; happier clients

Disadvantages of Value Engineering

- Reviews can delay the completion of project
- Contractor may be asked to assume professional liability
- Designer may be defensive in response to "criticism"

VE - The American System

Components	Alternatives
Function definition	Based on elemental function
Function evaluation	Lowest cost to perform function
FAST Diagram	Use
Allocate cost to function	Yes
Calculate worth	Yes
Generation of alternatives	Other creative techniques (ad hoc)
Organization of the study	Job plan
Group approach	External team
The value management facilitator	Independent
Format of value management study	40-hour workshop
Location	Outside work environment
The timing of the study	Sketch design
Evaluation of alternatives	Weighted matrix

VE - The British System

Components	Alternatives
Function definition	Based on project / space function
Function evaluation	Lowest cost to perform function
FAST Diagram	Use
Allocate cost to function	Yes
Calculate worth	No
Generation of alternatives	Ad hoc creative techniques
Organization of the study	Job plan
Group approach	Design team
The value management facilitator	Independent
Format of value management study	Two-day study
Location	Outside work environment
The timing of the study	Brief Sketch design
Evaluation of alternatives	Weighted matrix

VE - The Japanese System

Components	Alternatives
Function definition	Based on project / space function
Function evaluation	Lowest cost to perform function
FAST Diagram	Use
Allocate cost to function	No
Calculate worth	No
Generation of alternatives	Other creative techniques
Organization of the study	Job plan
Group approach	Design team
The value management facilitator	In-house
Format of value management study	Other as applicable to the project
Location	Within work environment
The timing of the study	Continuous process
Evaluation of alternatives	Subjective evaluation

My Conclusions on VE……

- The history of development of VE tells us a lot of things about its current state
- It is originally developed (and still widely applied) in a manufacturing environment, so some processes / procedures might not be directly applicable to construction

My Conclusions on VE……

- Most of the success stories come from the U.S. & Japan. In the U.S., it is implemented most effectively by government agencies such as the DOD and military who have the benefits of:
  - "Overpowering" the contractor in determining contractual terms
  - A team of employees who are disciplined enough for conducting such a study
  - A long stream of projects that allow for continual improvement on VE methodology
- The picture is quite different in the private sector and in other geographical regions such as Southeast Asia

Some Useful References

- Dell'Isola, A.J. (1997). *Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations*, R.S. Means Co.
- McGeorge, D. and Pamela, A. (1997). *Construction Management: New Directions*, Blackwell-Science, New York.
- Mudge, Arthur E. (1990). *Value Engineering: A Systematic Approach*, J. Pohl Associates, Pittsburgh, PA.
- Porter, Michael E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press, New York.
- Younker, Del L. (2003). *Value Engineering: Analysis and Methodology*, Marcel Dekker, New York.
- Zimmermann, Larry W. and Hart, Glen D. (1982). *Value Engineering: A Practical Approach for Owners, Designers and Contractors*, Van Nostrand Reinhold, New York.

52.248-3 Value Engineering--Construction

As prescribed in 48.202, insert the following clause:
Value Engineering – Construction
(March 1989)

(a) *General.* The Contractor is encouraged to develop, prepare, and submit value engineering change proposals (VECPs) voluntarily. The Contractor shall share in any instant contract savings realized from accepted VECPs, in accordance with paragraph (f) below.

(b) *Definitions.* "Collateral costs," as used in this clause, means agency costs of operation, maintenance, logistic support, or Government-furnished property.

"Collateral savings," as used in this clause, means those measurable net reductions resulting from a VECP in the agency's overall projected collateral costs, exclusive of acquisition savings, whether or not the acquisition cost changes.

"Contractor's development and implementation costs," as used in this clause, means those costs the Contractor incurs on a VECP specifically in developing, testing, preparing, and submitting the VECP, as well as those costs the Contractor incurs to make the contractual changes required by Governmental acceptance of a VECP.

"Government costs," as used in this clause, means those agency costs that result directly from developing and implementing the VECP, such as any net increases in the cost of testing, operations, maintenance, and logistical support. The term does not include the normal administrative costs of processing the VECP.

"Instant contract savings," as used in this clause, means the estimated reduction in Contract cost of performance resulting from acceptance of the VECP, minus the allowable Contractor's development and implementation costs, including subcontractors' development and implementation costs (see paragraph (h) below).

"Value engineering change proposal (VECP)" means a proposal that –

(1) Requires a change to this, the instant contract, to implement; and

(2) Results in reducing the contract price or estimated cost without impairing essential functions or characteristics; *provided*, that it does not involve a change –

(i) In deliverable end item quantities only; or

(ii) To the contract type only.

(c) *VECP preparation.* As a minimum, the Contractor shall include in each VECP the information described in subparagraphs (1) through (7) below. If the proposed change is affected by contractually required configuration management or similar procedures, the instructions in those procedures relating to format, identification, and priority assignment shall govern VECP preparation. The VECP shall include the following:

(1) A description of the difference between the existing contract requirement and that proposed, the comparative advantages and disadvantages of each, a justification when an item's function or characteristics are being altered, and the effects of the change on the end item's performance.

(2) A list and analysis of the contract requirements that must be changed if the VECP is accepted, including any suggested specification revision.

(3) A separate, detailed cost estimate for (i) the affected portions of the existing contract requirements and (ii) the VECP. The cost reduction associated with the VECP shall take into account the Contractor's allowable development and implementation costs, including any amount attributable to subcontracts under paragraph (h) below.

(4) A description and estimate of costs the Government may incur implementing the VECP, such as test and evaluation and operating and support costs.

(5) A prediction of any effects the proposed change would have on collateral costs to the agency.

(6) A statement of the time by which a contract modification accepting the VECP must be issued in order to achieve the maximum cost reduction, noting any effect on the contract completion time or delivery schedule.

(7) Identification of any previous submissions of the VECP, including the dates submitted, the agencies and contract numbers involved, and previous Government actions, if known.

(d) *Submission.* The Contractor shall submit VECPs to the Resident Engineer at the worksite, with a copy to the Contracting Officer.

(e) *Government Action.*

(1) The Contracting Officer shall notify the Contractor of the status of the VECP within 45 calendar days after the contracting office receives it. If additional time is required, the Contracting Officer shall notify the Contractor within the 45-day period and provide the reason for the delay and the expected

Figure 8.6

52.248-3 Value Engineering--Construction

date of the decision. The Government will process VECPs expeditiously; however, it shall not be liable for any delay in acting upon a VECP.

(2) If the VECP is not accepted, the Contracting Officer shall notify the Contractor in writing, explaining the reasons for rejection. The Contractor may withdraw any VECP in whole or in part, at any time before it is accepted by the Government. The Contracting Officer may require that the Contractor provide written notification before undertaking significant expenditures for VECP effort.

(3) Any VECP may be accepted, in whole or in part, by the Contracting Officer's award of a modification to this contract citing this clause. The Contracting Officer may accept the VECP, even though an agreement on price reduction has not been reached, by issuing the Contractor a notice to proceed with the change. Until a notice to proceed is issued or a contract modification applies a VECP to this contract, the Contractor shall perform in accordance with the existing contract. The Contracting Officer's decision to accept or reject all or any part of any VECP shall be final and not subject to the Disputes clause or otherwise subject to litigation under the Contract Disputes Act of 1978 (41U.S.C.601-613).

(f) *Sharing.*

(1) *Rates.* The Government's share of savings is determined by subtracting Government costs from instant contract savings and multiplying the result by

(i) 45 percent for fixed-price contracts or

(ii) 75 percent for cost-reimbursement contracts.

(2) *Payment.* Payment of any share due the Contractor for use of a VECP on this contract shall be authorized by a modification to this contract to--

(i) Accept the VECP

(ii) Reduce the contract price or estimated cost by the amount of instant contract savings; and

(iii) Provide the Contractor's share of savings by adding the amount calculated to the contract price or fee.

(g) *Collateral savings.* If a VECP is accepted, the instant contract amount shall be increased by 20 percent of any projected collateral savings determined to be realized in a typical year of use after subtracting any Government costs not previously offset. However, the Contractor's share of collateral savings shall not exceed (1) the contract's firm-fixed-price or estimated cost, at the time the VECP is accepted, or (2)$100,000, whichever is greater. The Contracting Officer shall be the sole determiner of the amount of collateral savings, and that amount shall not be subject to the Disputes clause or otherwise subject to litigation under 41U.S.C.601-613.

(h) *Subcontracts.* The Contractor shall include an appropriate value engineering clause in any subcontract of $50,000 or more and may include one in subcontracts of lesser value. In computing any adjustment in this contract's price under paragraph (f) above, the Contractor's allowable development and implementation costs shall include any subcontractor's allowable development and implementation costs clearly resulting from a VECP accepted by the Government under this contract, but shall exclude any value engineering incentive payments; *provided,* that these payments shall not reduce the Government's share of the savings resulting from the VECP.

(i) *Data.* The Contractor may restrict the Government's right to use any part of a VECP or the supporting data by marking the following legend on the affected parts:

"These data, furnished under the Value Engineering--Construction clause of contract....., shall not be disclosed outside the Government or duplicated, used, or disclosed, in whole or in part, for any purpose other than to evaluate a value engineering change proposal submitted under the clause. This restriction does not limit the Government's right to use information contained in these data if it has been obtained or is otherwise available from the Contractor or from another source without limitations."

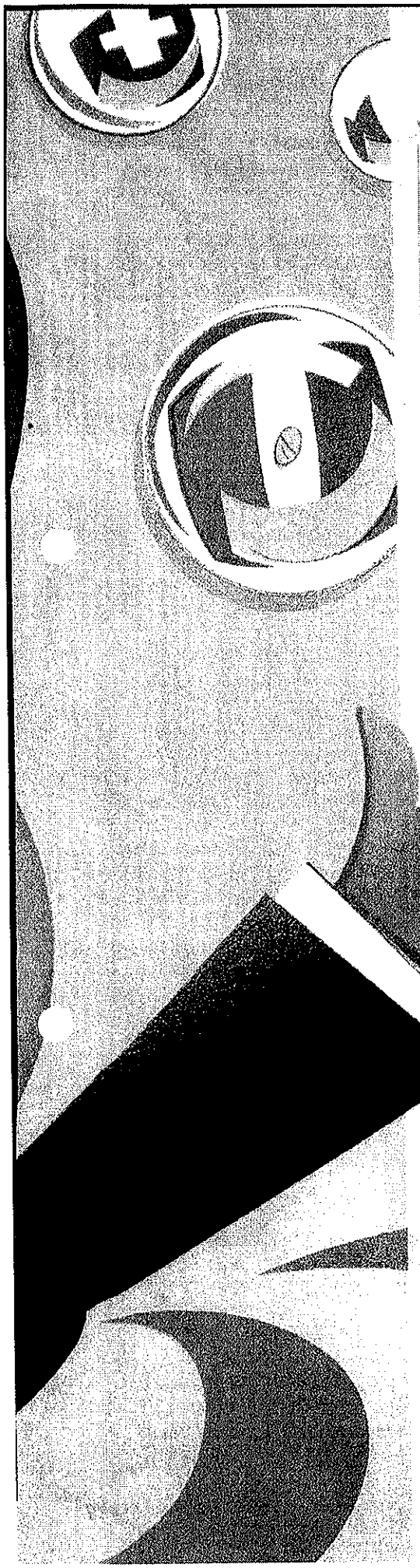
If a VECP is accepted, the Contractor hereby grants the Government unlimited rights in the VECP and supporting data, except that, with respect to data qualifying and submitted as limited rights technical data, the Government shall have the rights specified in the contract modification implementing the VECP and shall appropriately mark the data. (The terms "unlimited rights" and "limited rights" are defined in Part 27 of the Federal Acquisition Regulation.)

(End of clause)

Alternate I (APR 1984). When the head of contracting activity determines that the cost of calculating and tracking collateral savings will exceed the benefits to be derived in a construction contract, delete paragraph (g) from the basic clause and redesignate the remaining paragraphs accordingly.

Source: *Value Engineering Program Guide for Design and Construction*, PBS-PQ251, May 10, 1993, Vol. 2, p. 4-7.

Figure 8-6 (cont.)



"Being an international company – selling globally, having global brands or operations in different countries – isn't enough."

The Right Way to Go Global:

An Interview with Whirlpool CEO David Whitwam

by Regina Fazio Maruca

Everybody is talking about going global, but hardly anyone understands what that means, says David R. Whitwam, the 51-year-old chairman and CEO of the Whirlpool Corporation. According to Whitwam, too many managers are still running their businesses with the same old regional fiefdoms and inadequate ways of satisfying customers. As a result, few would-be global companies have escaped the deadly war of attrition in which cost and quality are the only weapons and ever-declining margins the only prize.

When Whitwam became CEO in 1987, Whirlpool was mired in just such an unwinnable war in the North American major-appliances market. Whitwam, who joined Whirlpool in 1968 and rose through the sales and marketing ranks, was determined to make whatever changes necessary to secure real growth for the future. Whitwam's vision of global opportunity led to Whirlpool's daring $1 billion purchase of N.V. Philips's floundering European appliance business in 1989, a move that catapulted Whirlpool into the number-one position in the worldwide appliance business.

Whitwam could have chosen to "fix" Philips through cost-cutting and operating changes. Instead, he followed a more ambitious path: transforming two parochial, margin-driven companies into a unified, consumer-focused organization capable of using its combined talents to achieve breakthrough performance in markets around the world. As a result, the new Whirlpool set the pace for the global appliance industry and its price structure.

Whitwam is the first to admit that the transformation is not complete. He discussed the lessons Whirlpool has learned – and continues to learn – with HBR associate editor Regina Fazio Maruca at company headquarters in Benton Harbor, Michigan.

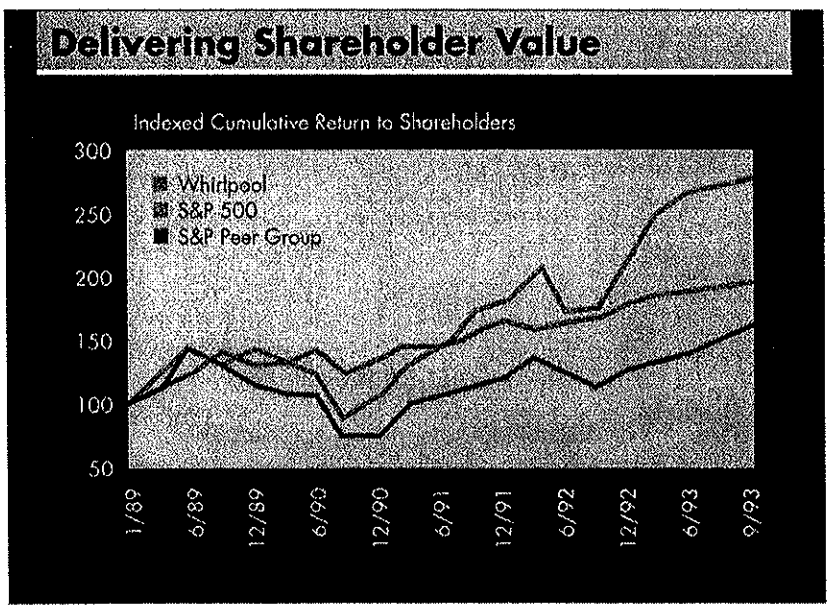
DRAWINGS BY ROBERT RISKO

HBR: *In 1987, Whirlpool was primarily a North American company. Today it manufactures in 11 countries with facilities in the United States, Europe, and Latin America and markets products in more than 120 locations as diverse as Thailand, Hungary, and Argentina. What's the most crucial lesson you've learned about how a company builds a global competitive advantage?*

David Whitwam: The only way to gain lasting competitive advantage is to leverage your capabilities around the world so that the company as a whole is greater than the sum of its parts. Being an international company – selling globally, having global brands or operations in different countries – isn't enough.

In fact, most international manufacturers aren't truly global. They're what I call flag planters. They may have acquired or established businesses all over the world, but their regional or national divisions still operate as autonomous entities. In this day and age, you can't run a business that way and expect to gain a long-term competitive advantage.

To me, "competitive advantage" means having the best technologies and processes for designing, manufacturing, selling, and servicing your products at the lowest possible costs. Our vision at Whirlpool is to integrate our geographical businesses wherever possible, so that our most advanced expertise in any given area – whether it's refrigeration technology, financial reporting systems, or distribution strategy – isn't confined to one location or one division. We want to be able to take the best capabilities we have and leverage them in all of our operations worldwide.



In the major-appliances industry, both the size of our products and varying consumer preferences require us to have regional manufacturing centers. But even though the features, dimensions, and configurations of machines like refrigerators, washing machines, and ovens vary from market to market, much of the technology and manufacturing processes involved are similar. In other words, while a company may need plants in Europe, the United States, Latin America, and Asia to make products that meet the special needs of local markets, it's still possible and desirable for those plants to share the best available product technologies and manufacturing processes.

"When we bought Ph Italian and German fa

Let me use washing machines as an example. Washing technology is washing technology. But our German products are feature-rich and thus considered to be higher-end. The products that come out of our Italian plants run at lower RPMs and are less costly. Still, the reality is that the insides of the machines don't vary a great deal. Both the German and the Italian washing machines can be standardized and simplified by reducing the number of parts, which is true of any product family. Yet when we bought Philips, the washing machines made in the Italian and German facilities didn't have one screw in common. Today products are being designed to ensure that a wide variety of models can be built on the same basic platform. Our new dryer line has precisely this kind of common platform, and other product categories are currently being designed in the same way.

But before you can develop common technologies and processes, don't you have to define the new organization's goals?

Absolutely. You must create an organization whose people are adept at exchanging ideas, processes, and systems across borders, people who are absolutely free of the "not-invented-here" syndrome, people who are constantly working together to identify the

best global opportunities and the biggest global problems facing the organization. If you're going to ask people to work together in pursuing global ends across organizational and geographic boundaries, you have to give them a vision of what they're striving to achieve, as well as a unifying philosophy to guide their efforts.

kind of company it wanted to become in the next decade or the next century. This lack of self-scrutiny isn't as surprising as it might sound. Whirlpool was successful, profitable, and reasonably secure in a domestic market that was already eliminating the marginal competitors. The world hadn't broken down our doors the way Japanese automakers had

ilips, the washing machines made in the cilities didn't have one screw in common."

That's why we've worked so hard at Whirlpool to define and communicate our vision, objectives, and the market philosophy that represents our unifying focus. Our vision is to be one company worldwide. Our overarching objective is to drive this company to world-class performance in terms of delivering shareholder value, which we define as being in the top 25% of publicly held companies in total returns through a given economic cycle. (See the graph, "Delivering Shareholder Value.")

Our market philosophy suggests that the only way to deliver this value over the long term is by focusing on the customer. Only prolonged, intensive effort to understand and respond to genuine customer needs can lead to the breakthrough products and services that earn long-term customer loyalty. Too many companies implement one improvement program after another but ignore the larger picture, which has to do with establishing enduring relationships between a company and its customers. Many companies would like to think that if they become "world-class" in cost and quality, they'll win. But it takes more than that.

Why do you think so many international companies aren't managed as global businesses?

Top-level managers often incorrectly assume that since consumers differ from location to location, their businesses can't operate effectively as a unified entity. As a result, they see their industry as a mosaic of specialized businesses, each with its own unique constraints and its own finite opportunities. They look at these "little pictures" when they're creating strategies, and because it's so hard for them to back away from such close-up views, many can't entertain the notion that their industry could evolve into something different over time.

Until the mid-1980s, Whirlpool was no different. When we sat down to plan our future in 1987, it was the first time Whirlpool had ever asked itself what stormed Detroit, for example. If you're a market leader with no imminent catastrophe on the horizon, critical self-examination is more the exception than the rule. But we faced up to that challenge because we could see our future growing more difficult and complicated with each passing year.

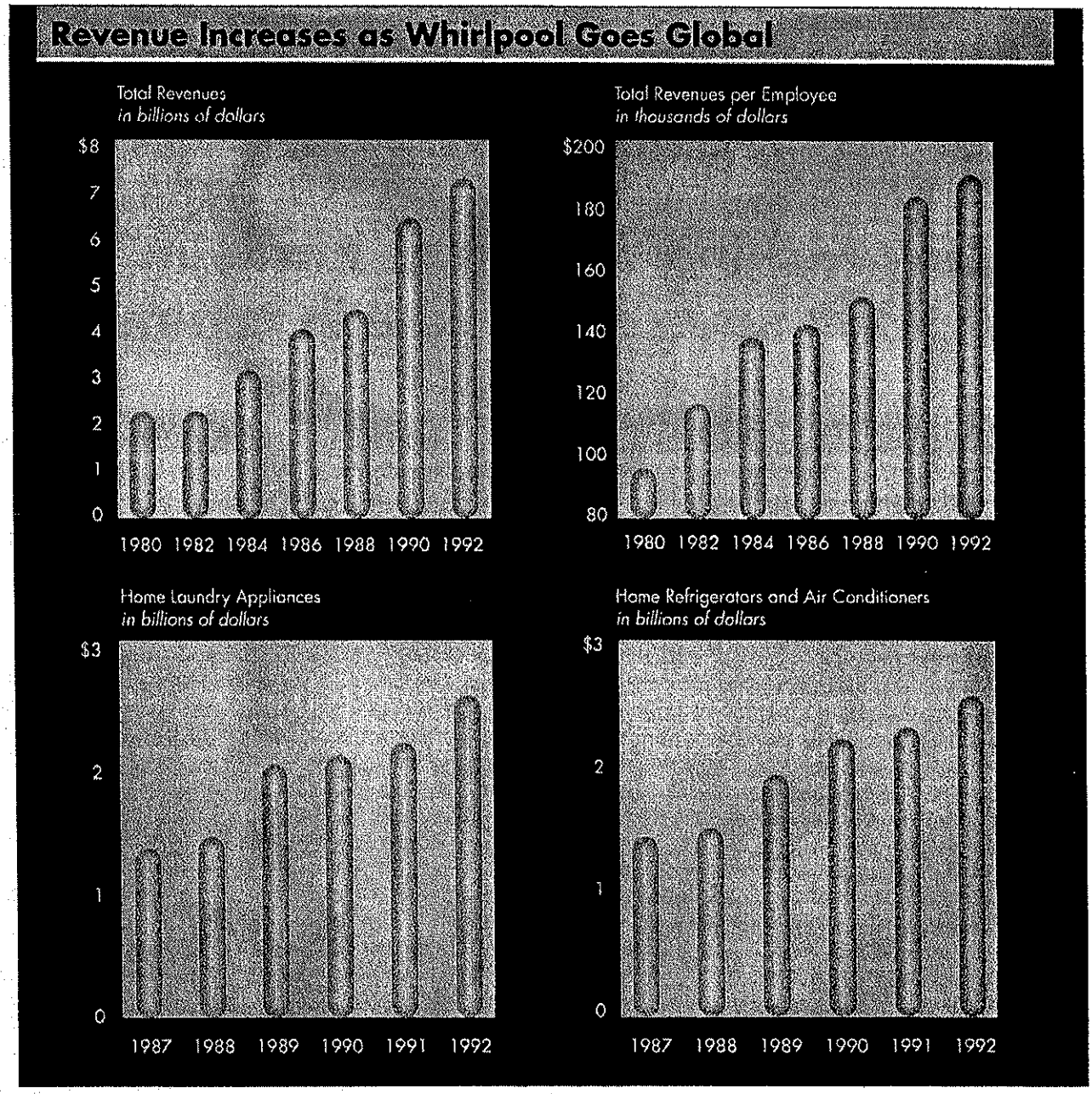
How did Whirlpool come to the decision to globalize through this process of self-examination?

We didn't start with the answer that we were going to globalize. We started with the knowledge that if we stuck to the path we were on, the future would be neither pleasant nor profitable. Even though we had dramatically lowered costs and improved product quality, our profit margins in North America had been declining because everyone in the industry was pursuing the same course and the local market was mature. The four main players – Whirlpool, General Electric, Maytag, and White Consolidated, which had been acquired by Electrolux – were beating one another up every day.

So we explored our options. We could have restructured the company financially and paid out a lot to our shareholders. We also looked at diversifying the business. If the major-appliances industry didn't offer growth, were there other industries that did? We looked at other kinds of durable products. We looked at horizontal expansion and vertical expansion. And in the process, it became clear to us that the basics of managing our business and its process and product technologies were the same in Europe, North America, Asia, and Latin America. We were already very good at what we did. What we needed was to enter appliance markets in other parts of the world and learn how to satisfy different kinds of customers.

Before 1987, we didn't see the potential power our existing capabilities could give us in the global market because we had been limiting our definition of the appliance market to the United States. Obvi-

Revenue Increases as Whirlpool Goes Global



ously, this also limited our definition of the industry itself and the opportunity it offered. Our eight months of analysis turned up a great deal of evidence that, over time, our industry would become global, whether *we* chose to become global or not. With that said, we had three choices. We could ignore the inevitable – a decision that would have condemned Whirlpool to a slow death. We could wait for globalization to begin and then try to react, which would have put us in a catch-up mode, technologically and organizationally. Or we could control our own destiny and try to shape the very nature of globalization in our industry. In short, we could force our competitors to respond to us.

Before we began making moves on the global stage, Electrolux was out in front of us. It had bought White Consolidated and had acquired several appliance makers in Europe. But Electrolux appeared to be taking advantage of individual opportunities rather than following a coordinated plan. After our Philips acquisition, we also saw General Electric take some opportunistic steps.

Today, however, Whirlpool is the front-runner when it comes to implementing a pan-European strategy and leveraging global resources. By expanding our strategic horizon, not just our geographic reach, we've been able to build a global management capability that provides us with what we feel

is a distinct competitive advantage. Clearly, this should enable us to improve returns to our shareholders significantly.

The notion that managers should think "global but act local" isn't a new thought. But it seems to have proven to be a lot easier said than done.

The key is getting your organization – and not just top management – to think globally. Most companies never get to that stage because their leaders haven't understood what they can and cannot do. A CEO can forcibly position his or her organization at the beginning of the path to globalization and help employees take the first step or two. But ultimately, employees must cover the miles with their own feet. CEOs have to create the processes and structures to get the organization going and keep people aimed in the right direction, but they cannot achieve anything requiring sustained effort by edict alone. Organizations have changed radically in recent years. When the chairman walked down the halls in my early years with Whirlpool, you found an office to duck into. According to the old paradigm of hierarchy and discipline, it wasn't his subordinates' place to question his decisions.

"Employees today question and challenge all the time."

Employees today question and challenge all the time. They don't accept things at face value. As a result, a contemporary CEO has to convince employees why transformation is necessary. Then there's the critical step of persuading them that they can perform at what seem to be impossibly high levels. For a company to become a truly global enterprise, employees have to change the way they think and act, taking on progressively more responsibility and initiative until the company behaves globally in all of its parts – without the CEO cracking a whip.

So change at the global level requires more patience than many senior executives seem to have.

In our society, there seems to be an expectation that CEOs should be able fix things in a flash, even if that entails engineering an organizational transformation overnight. When we acquired Philips, for example, Wall Street analysts expected us to ship 500 people over to Europe, plug them into the plants and distribution systems, and give them six months or a year to turn the business around. They expected us to impose the "superior American way" of operating on the European organization.

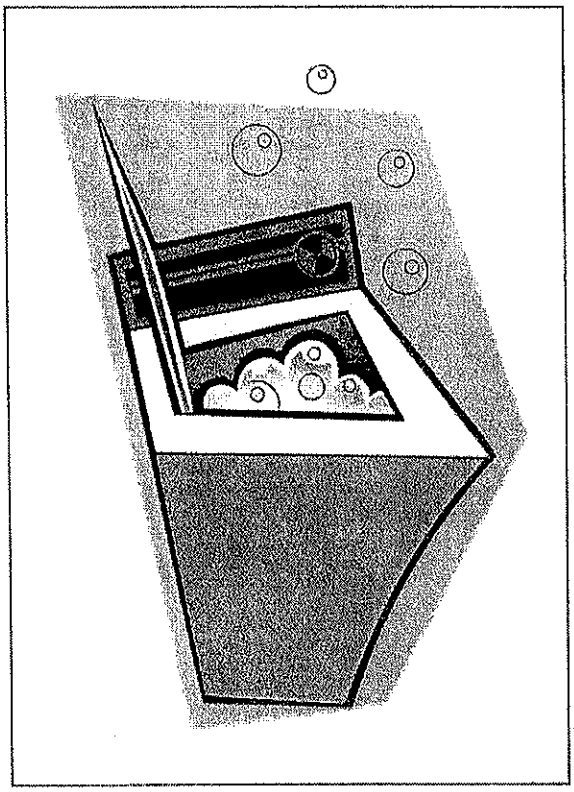
But you have to remember that we were planning to build a global enterprise, not a U.S. army of occupation. If you try to gain control of an organization by simply subjugating it to your preconceptions, you can expect to pay for your short-term profits with long-term resistance and resentment. That's why we chose another course. During that first year, I think we had two people from the United States working in Europe, and neither was a senior manager. By the end of the second year, we had maybe half a dozen U.S. managers there – again, none at senior levels. We listened and observed. We worked hard to communicate the company's vision, objectives, and philosophy to the European workforce. Building a shared base of understanding takes time, and we had to learn how to do that in a multilingual, multinational environment. Today we have 15,000 employees in Europe with only 10 from U.S. operations. They all report to European bosses, with the exception of Hank Bowman, executive vice president of Whirlpool Europe.

The hardest part of globalization is avoiding the temptation of trying to build Rome in a day. The purchase contract might state that you own the land. But you don't own the builders; they have to enter into the work contract of their own free will.

It's one thing to get senior managers to buy into globalization. How do you persuade employees throughout the organization?

Very slowly. You can't expect it to happen overnight. Bear in mind that we have many, many employees in our manufacturing plants and offices who have been with us for 25 or 30 years. They didn't sign up to be part of a global experience. Most of our North American employees joined Whirlpool to live in places like Benton Harbor, Michigan, or Clyde, Ohio – not Cassinetta, Italy. And a lot of our Italian colleagues didn't join Philips to work in the United States. In addition, we have a fairly large group of managers around the world, including me, who have acquired all of their experience in very traditional, hierarchical organizations. Suddenly we give them new things to think about and new people to work with. We tell people at all levels that the old way of doing business is too cumbersome.

Changing a company's approach to doing business is a difficult thing to accomplish in the United States, let alone globally. In the beginning, our North American Appliance Group didn't want any part of this new one-company vision. They saw it as a threat. They thought, "Whitwam's running off and spending a billion dollars in Europe, and that's going to take away resources that we need to succeed." In addition, when we first took engineers and manufacturing people from the United States to Europe to go through the plants, they would spend all their time walking around and saying to themselves, "We do all of these things better at home." The Europeans who toured the U.S. facilities had the same parochial attitude. Neither group spent any time looking at what it could learn from the other.



During the first two years after we acquired the Philips business, we didn't concentrate on immediately improving performance. Instead, we spent a lot of time building trust and creating a common vision of our future. We deliberately encouraged our employees to think like owners so that they would come to believe that it was in their best interest to create a global organization. When we started the process, I told the organization that the only reason we existed as a large publicly held company was to create value for the shareholders. Now, the employee who works on a production line or in an office down the hall doesn't necessarily feel very good about that. Think about all the negative stereotypes of fickle shareholders. I explained that creating value for shareholders was the only way we could hope to create value for all our other stakeholders – employees, the communities we live in, our suppliers, and so on. Seeing the connections among interests is a key part of acquiring the global, one-company mentality we need. People don't see that vision just because you say it.

One of the approaches we're using to help employees feel like owners is to give them more responsibility. We need their heads thinking as well as their hands working. In some of our factories today, there is no supervisor on the floor. Teams made up of hourly workers hire new employees, create production line layouts, decide on production levels, and even make employee termination recommendations. They drive the quality process. That's a real change from how industrial companies have traditionally been managed.

Another approach is our compensation system. Its driving principle is "pay for performance." For example, essentially all of our U.S. employees received stock options in 1991. Some operations have gain-sharing programs, which allow employees to benefit directly from their own productivity and quality improvements. Other programs, including our 401K program, pay people – from top management to those on the factory floor – on the basis of whether or not we achieve corporate return-on-equity (ROE) or return-on-net-asset (RONA) goals. Employees at Whirlpool all understand what ROE and RONA mean, what drives those measurements, and how they're linked to shareholder value.

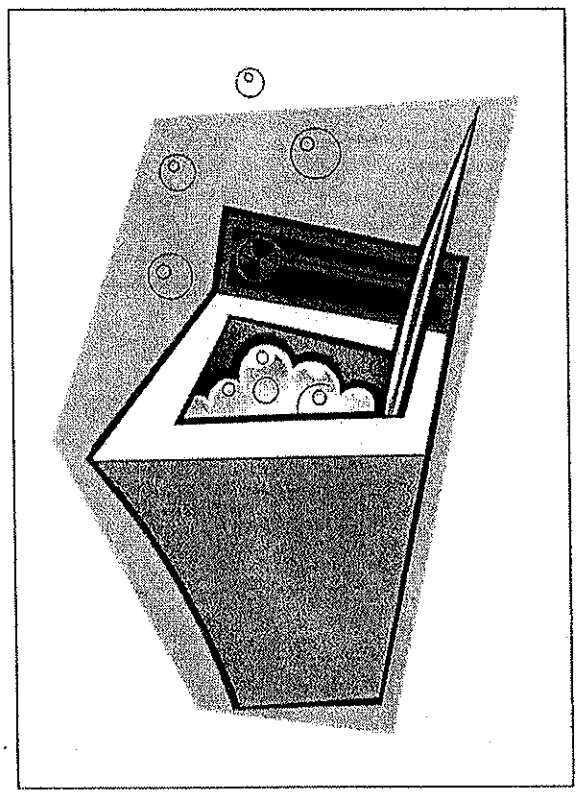
It's one thing to empower employees and communicate to them the importance of a common vision. But how did you translate that vision into the fabric of the organization – the day-to-day operations?

By helping employees throughout the organization do it for themselves. Six months after we acquired Whirlpool Europe, we brought 150 of our senior managers to Montreux, Switzerland, and we spent a week developing our global vision. What did it mean? What were the implications? The benefits of a week of "feel good" discussion didn't end when the meeting adjourned, because everyone who attended took away an assignment.

We made those 150 people accountable for educating all of our 38,000 people around the world. When going global, you have to communicate to everyone what the company vision is and what the long-term goals are. And then you have to follow through and design processes that force the interaction to continue. Every single employee must be-

lieve that there is great value in managing the company in an integrated way. To do that, you have to bring people together on real projects that tackle real problems or that explore opportunities on a cross-border basis.

To that end, managers at Montreux commissioned 15 projects – what we call One-Company Challenges. They ranged from creating a global product-strategy review process to developing a product-creation process worldwide to establishing a talent-pool system for human resources. Each of these challenges had to have a major impact on the realization of the vision. Each person who attended the meeting at Montreux went back home and gathered a team of employees from all levels of the company to work on a given project.



One of the One-Company Challenges was creating a companywide total-quality-management system, which we now call the Whirlpool Excellence System (WES). When we acquired Philips, we suddenly had one organization that focused on ISO-9000, the European total quality system, and another that focused on the U.S. Baldrige approach to quality.

Instead of imposing one approach on the entire organization, we created a cross-cultural team with members from Europe and North America and asked them to examine the best quality programs in the world, including ISO-9000 and Baldrige. The team then developed a global quality system that was appropriate for the new Whirlpool. The result was WES. It was this Euro-American group that then designed all the details of WES, including the training, communications, and deployment programs needed to create a common approach – a common language of quality – for all our operations.

A company needs to have one management process, one understanding of performance requirements. But it takes more than one person to design that management process if it is to be accepted, used, and turned into a competitive advantage. One of the best ways to change an inflexible mind-set is to expose people to both challenges and the new ideas that can meet those challenges. When they've completed the work at hand, they've also gained a new sense of what is possible and desirable.

Was setting the process of globalization in motion at Montreux all that was required?

No. First, I should stress that we are not "there" yet. Although we've made a lot of progress, we are not yet a truly global organization. It will take more time to become one. Second, I want to make it clear that the art of management is not confined to orchestrating the creation of a bold vision, a great plan, or even one set of actions that causes the organization to face up to the need for change. It must also encompass relentless follow-through, meticulous attention to detail, and the establishment of personal accountability throughout the organization. These are not glamorous functions, perhaps, but like conscience and memory in a human being, they are all that protect good intentions from the distractions of the moment. Without them, the organization cannot maintain interest or momentum, and the initiative – no matter how spectacular the fireworks of the start-up – will fizzle out.

An initiative like globalization doesn't acquire momentum just because it is enormous. You have to push hard to overcome the initial inertia, and then you have to keep pushing so that friction – in the form of fear, uncertainty, and confusion – doesn't stop it in its tracks. We made a good start with the Montreux conference, then brought the same delegates together again the following year, this time in Washington, D.C. There, we studied the implications of WES and developed a whole new set of projects to continue to change company behavior. The Washington delegates were assigned the job of establishing 15 or 20 One-Company Teams to carry out the new projects.

You have to remind everyone over and over again that the new organization and its tenets aren't going to disappear. In addition to annual meetings of our top 150 managers, we have been bringing all de-

velopment, marketing, and manufacturing leaders together twice a year for global product and technology reviews. We examine our product designs and how consumer needs affect them. Nothing came of it the first year in terms of actual global product creation. But you must expect that. Even if nothing concrete comes out of it, a preliminary session is still creating awareness that building a washing machine in Clyde, Ohio, isn't different from building one in Schorndorf, Germany.

You've made it sound as if an organization can globalize without outside help. Can a collection of regional organizations transform themselves in such short order without an injection of new skills or perspectives?

Absolutely not. When you change a company as rapidly as we did, you wake up one morning and suddenly realize that you don't have the skills and experience you need, and that includes the CEO. I had never run a multinational company until January 1, 1989, when we bought Philips. I've often said that there's only one thing that wakes me up in the middle of the night. It's not our financial performance or economic issues in general. It's worrying about whether or not we have the right skills and capabilities to pull the strategy off.

Traditionally, Whirlpool executives were homegrown. They came up through the ranks, and their knowledge and experience were limited to North America. Needless to say, we experienced some pain as we tried to match existing skills with emerging global management requirements. There were shortfalls at every level, including my own. In some cases, they could be remedied by education and training programs. But some could only be remedied by recruiting from the outside.

It is a simple and inescapable fact that the skills and capabilities required to manage a global company are different from those required for a domestic company. But that's a leap we wanted to make, one that we chose in the interest of the company and its shareholders. And that tends to be a helpful factor when you're negotiating the hard parts: you know you're making these tough changes because you're dramatically increasing the overall opportunity for the company and its employees.

We've moved into a different realm, and there is no turning back. For example, there is no question in my mind that the person who replaces me as CEO and chairman will need experience managing in a foreign environment.

But isn't Whirlpool still planting flags too? For example, you have sales and distribution subsidiaries in Hong Kong, Thailand, and Taiwan, but you have no Asian manufacturing operations.

It may indeed look like flag planting, but that is not our intention. When you enter a new market, your sales organization, your knowledge of the local consumer, and your overall capabilities have to develop to a certain level before your business can hope to become a full-fledged, participating member of the global organization. That is the goal for our Asian business.

In 1988, we began in Asia with what I called the learning phase of the strategy, which resembled flag planting. But the purpose was to build a distribution system in Southeast Asia and to gain an understanding of the consumer. Within the past year, we have opened three regional offices in Asia: an office in Singapore to serve Southeast Asia, an office in Hong Kong to serve Greater China, and an office in Tokyo to serve Japan. We also currently have a design, engineering, and product development center in Singapore for all of Asia, which will help us reach the point at which we can manufacture in our own facilities in Asia. We know when and where these facilities will be established.

Our interim plan is to have a cadre of 80 to 100 people in the Singapore center who can call on Whirlpool resources around the world to shape and direct the plants and the products we produce in Asia. So when we start manufacturing in Asia, it will be as a global company. The beauty of starting a new operation like this one is that you don't have to overcome decades of managing habits that are ineffective when creating a global organization.

You seem to believe that truly global companies can leave their competitors in the dust by scoring breakthroughs in satisfying customers. Given that none of the major players in your industry has been able to pull away from the pack by dramati-

"If you want to open the door to imaginati isn't it more useful to think of the 'fabric-care

cally slashing costs and improving quality, is this goal a fantasy?

No, it's not a fantasy. Whirlpool, its biggest competitors, and many companies in other industries have been too obsessed with cost and quality at the expense of other variables. You can't achieve a competitive advantage by focusing exclusively on cost and quality. Everybody in this industry is driving down the same cost and quality curve. And let's assume we're all going to become world-class performers. When that occurs, you'll have a handful of companies building great products that will last for 80 years, but no one will make any margins on them. And what then gives one product the edge over another?

on and innovation, business'?"

Our strategy is based on the premise that world-class cost and quality are merely the ante – the price of being in the game at all. We have to provide a compelling reason other than price for consumers to buy Whirlpool-built products. We can do that only by understanding the consumer better than anyone else does and then translating our understanding into clearly superior product designs, features, and after-sales support. Our goal is for consumers to prefer the Whirlpool brand because it offers greater overall value than competing products. Achieving that goal requires taking a giant step back from our business and rethinking who our customers are and what their needs are. This may not sound earth-shattering, but it is. It means rethinking the very nature of the business.

All of us in this industry have been telling ourselves that we're in "the refrigerator business," "the washing-machine business," or "the range business." None of us saw a great deal of room for product innovation, which is undoubtedly why there hasn't been radical innovation in 30 years, apart from the microwave oven and the trash compactor. If you want to open the door to imagination and innovation, isn't it more useful to think of "the fabric-care business," "the food-preparation business," and "the food-preservation business"?

The starting point isn't the existing product; it's the function consumers buy products to accomplish. When you return to first principles, the design issues dramatically change. The microwave couldn't have been invented by someone who assumed he or she was in the business of designing a range. Such a design breakthrough required seeing that the opportunity is "easier, quicker food preparation," not "a better range."

We are applying these broader definitions in very direct ways. Organizationally, we have created what we call an advanced product development capability to serve markets around the world. Its charter is to look beyond traditional product definitions to the consumer processes for which products of the future will have to provide clear benefits.

Take "the fabric-care business," which we used to call the "washing-machine business." We're now studying consumer behavior from the time people take off their dirty clothes at night until they've been cleaned and ironed and hung in the closet. What are we looking for? The worst part of the process is not the washing and drying. The hard part is when you take your clothes out of the dryer and you have to do something with them – iron, fold, hang them up. Whoever comes up with a product to make this part of the process easier, simpler, or quicker is going to create an incredible market.

In other words, you're redefining what it means to satisfy the customer?

Our purpose at Whirlpool is to build a perfect product. With that as the point of departure, you can indeed take the notion of satisfying the customer to a completely different plane, and that's where breakthroughs become possible. Reaching such a plane means studying consumers' lifestyles to decipher what they might want even if they cannot articulate that desire in terms of a product request. Ten years ago, what consumer would have said he needed a CD player? Yet today records have virtually ceased to exist. Note that a company could have missed this breakthrough by asking the wrong questions of consumers or by narrowly interpreting consumer answers to good questions. In fact, consumers often speak in code. For example, our market research showed that customers wanted "clean refrigerators." Did this mean refrigerators that were easy to clean? No. We figured out that it

"Our purpose at Whirlpool is to build a perfect product."

meant refrigerators should look clean and hide finger marks, which helped us come up with a textured finish.

In rapidly segmenting consumer markets, you have to understand not only the lifestyles that people have today but also the kinds of lifestyles they are going to have five years from now and beyond. Can you tell me what you want your refrigerator to look like in the year 2010? Of course not. So we have to move away from the traditional approach of reacting to what customers say they want.

How do you do that?

One way is to develop close relationships with organizations in related businesses. For example, we have had a close, well-defined contractual relationship with Procter & Gamble in the United States. We have a long-standing relationship with them, exchanging basic information, ideas, and so forth. But now we have a more intense involvement at the development, engineering, and technology levels. We've established a formal partnership, in which one party is not worried about sharing proprietary information with the other.

We also work with Unilever in Brazil. Our engineers work together on product development, because both companies need to understand where the other is going over the long term. Unilever is working with other manufacturers too, because they can't be designing detergents ten years out for washing machines that can't use them.

Finally, we're moving toward a significant consolidation of our suppliers. Instead of working with five steel suppliers, for example, we want to have an important partnership with one or two. We want to have agreements that give us access to supplier technologies so that we can work together on process improvements in all of our plants. That's difficult to do with a broad supplier base.

As well as redefining customer satisfaction, are you redefining who your customers are?

Yes. There are numerous companies and many improvement experts who talk about satisfying internal customers. At Whirlpool, we once did the same, but we currently believe that internal customers do not exist. In fact, the only customer is the final consumer.

Companies that believe they have internal customers – that manufacturing is marketing's customer, for example – lose sight of what they're trying to accomplish as an organization. Today we're organized around multifunctional processes that are focused on serving the end user. Take, for instance, the product business teams we've established. They behave completely differently than functions at Whirlpool behaved in the past. We used to make a lot of dumb decisions in manufacturing for the sake of manufacturing. We don't do that nearly as much today. The product business teams are meant to divert the focus from the function to the consumer.

Of course, we have to be careful to prevent any weakening of functional excellence. The job of our vice president of manufacturing for the North American Appliance Group is to drive functional excellence. You have to keep benchmarking single functions even as you're working multifunctionally. It's a tough balance. But it's an ongoing effort.

How does this approach change the relationship between the manufacturer and the retailer?

Until you stop thinking about retailers as customers and start thinking about them as part of the process, you're going to be delivering the wrong kinds of products. For too long, we viewed the retailer as a customer.

Sears, Roebuck & Company is a great example. Until 1947 or so, Sears was our only retailer, and we still do in excess of a billion dollars of business with them. But for too much of our relationship, we treated Sears as a customer. We developed products to sit on their floors in competition with other products that were sitting on their floors. If they said, "I want this washing machine with three whistles and two bells, and I want it to be pink," we gave it to them. Little did we know that the consumer didn't want machines with whistles. Today we don't treat each other as customer/supplier. We see ourselves as partners trying to solve a consumer need.

"Complacency should have no part in any organization."

What is the end of the road? When will you know that Whirlpool has become global?

Strictly speaking, there is no end of the road. Continuous change is the essence of the global market. But there are some milestones I look forward

to. For example, I'll know we've arrived as a global company when we have cross-border product business teams – one for washing machines, one for refrigerators, one for ovens, and so on – running all of our operations throughout the world. These teams, which will have functional and brand objectives, will identify the best opportunities and the most important problems to solve and then assess the related trade-offs.

There will also come a day when we'll identify a location where the best skills in a certain product area should be concentrated, and that place will become the development center for that type of product. But here's an important distinction: while we may have only one major design center for a given product, not everyone associated with that product will have to be located there. For example, the development center for refrigeration products may be in Benton Harbor, but we may also have people working for that center in China or Italy. Think about the communication technologies that exist today. People don't need to sit next to each other anymore to work together on the same project. In fact, it's no longer appropriate or effective to design organizations that way. Instead, global competitors will increasingly make use of "virtual teams," as we – and others – are already doing.

Admittedly, we're not an "old hand" at virtual teams yet. But we have used them effectively. For example, we recently developed a super-efficient, chlorofluorocarbon-free refrigerator that won a contest sponsored by a group of U.S. utilities. We used insulation technology from our European business, compressor technology from our Brazilian affiliates, and manufacturing and design expertise from our U.S. operation. If we had still been the kind of company we were in 1987, we couldn't have pulled off this kind of cross-border teamwork.

As we look to the future, perhaps the greatest trap will be our own successes. Success has a way of drawing attention away from the present and future and onto the past. The history of business is littered with companies that were short-term successes. Complacency should have no part in any organization. It is the responsibility of leaders to manage against it.

Reprint 94210



"I'm a mercenary."

CARTOON BY GEORGE DOLE