

Value Engineering Project Workbook

This workbook is designed to provide guidance in carrying out a Value Engineering Project study. The instructions, check lists and worksheets should assist the analyst in the application of the Value Engineering Job Plan and each technique. Although primarily intended to be used as a workbook during seminars, it can be used for task force and other value engineering studies. It is not a complete text or training manual in the field of Value Engineering or Analysis.

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TABLE OF CONTENTS

	Page
SECTION I INTRODUCTION	5
1. History of Value Analysis/Value Engineering	5
2. Why Unnecessary Costs	6
3. Why Value Engineering	7
SECTION II VALUE ENGINEERING JOB PLAN AND TECHNIQUES	9
1. Description	9
2. Chart of Techniques	11
3. General Techniques	13
SECTION III VALUE ENGINEERING STUDIES	15
1. Selection of Value Engineering Projects	15
2. The Team Approach	16
SECTION IV PHASE I OF THE VALUE ENGINEERING JOB PLAN	17
1. Description of Information Phase	17
2. Check List	21
3. Worksheet	23–25
SECTION V PHASE II OF THE VALUE ENGINEERING JOB PLAN	27
1. Description of Creation Phase	27
2. Check List	29
3. Worksheet	31
SECTION VI PHASE III OF THE VALUE ENGINEERING JOB PLAN	33
1. Description of Evaluation Phase	33
2. Check List	35
3. Worksheet	37
SECTION VII PHASE IV OF THE VALUE ENGINEERING JOB PLAN	39
1. Description of Investigation Phase	39
2. Check List	43
3. Worksheet	45–47
SECTION VIII PHASE V OF THE VALUE ENGINEERING JOB PLAN	49
1. Description of Recommendation Phase	49
2. Check List	51
3. Worksheet	53–55
SECTION IX REFERENCE MATERIAL	57
1. Cost & Function Analysis Techniques	57
SECTION X INDEX	65
1. Index and Glossary of Terms	65

SECTION I INTRODUCTION

Part 1. The History of Value Analysis/Engineering

The end of World War II marked the beginning of the end of horse and buggy approaches to cost reduction and industrial cost effectiveness. To one man of unusual foresight, Mr. Harry Erlicher, Vice President of Manufacturing—General Electric Company, it was a period where innovation was forced by material shortages. The results of these changes, he observed, often were lower costs and improved products. This caused him to think along the lines of more intentional approaches and organized methods to give their customers more for their money, greater *Value*.

The outgrowth of this was that a man named Larry Miles was assigned the task, defined generally as "find a more effective way to improve product *Value*." This was in 1947. For the next five years, Mr. Miles and his associates researched in the area of product costs and value. They performed many analyses of value to search out unnecessary costs. Gradually they accumulated a package of techniques and assembled a system known as Value Analysis. As a result of nearly a three million dollar investment a new methodology was developed, tested and proven to be highly effective.

While many people became acquainted with Value Analysis during this development period, it was not until 1952 that it began its rapid growth throughout industry. In this year, Mr. Miles conducted the first Value Analysis workshop seminar. Some sixty people from various General Electric plants and business functions obtained 160 hours of basic training in Value Analysis techniques. Many of these people returned to their plants as full time Value Analysts and started V.A. programs. From the seminar and the various departmental activities this approach to cost reduction received nationwide publicity. Moreover, many representatives of other companies attended V.A. seminars as suppliers or worked with Value Analysts on cost reduction projects. As a result the techniques were adopted by many different industries. Organizations such as the National Association of Purchasing Agents and publications such as "Purchasing" promoted use of the techniques.

In the late 50s, trade associations such as the Electronic Industries Association endorsed Value Analysis and established committees with members from industry and Government to promote Value Analysis as an industrial and professional activity. The EIA conducted three national conferences on Value Analysis which did much to arouse the interest and participation by industry and Government. In 1959 the Society of American Value Engineers was formed in Washington, D. C. to unite all practitioners and promote the growth of the profession.

As a result of these activities and the outstanding results produced by the application of V.A. techniques, the vast

majority of American industry today has adopted these concepts to help them improve profits and their competitive position.

Since the middle 50s, when the Navy Bureau of Ships became interested in the General Electric Value Analysis program and established a Value Engineering Branch, the Government's interest in this field has continued to grow. It might be pointed out here that the terms Value Analysis and Value Engineering are considered synonymous as far as an identification of the methodology is concerned. Usually the word "engineering" is used when the techniques are applied during product design and development. While the Navy's early interest in Value Analysis was to help them reduce the cost of shipbuilding, it soon became evident that all Governmental agencies could employ the concepts both to help them reduce internal expenses and to reduce the cost of purchased equipments.

It was toward this latter objective that the Value Engineering Contractual Clauses came into existence. Starting as a means to motivate Navy contractors to apply Value Analysis, the concept attracted the interest of other Government branches and finally was adopted by the Department of Defense and applied as a mandatory part of all Government procurement. Today, the Armed Services Procurement Regulations (ASPR) specify that all contracts over certain dollar value must include either a V.E. Program or Incentive clause. A Program clause requires that the contractor do value engineering as a funded line item in the contract and provides for limited sharing of any savings. An Incentive clause provides an opportunity for the contractor to share a greater percentage of the net savings which result from a V.E. proposal which he submits. The proposal suggests a lower cost way the Government can obtain the desired function. The contractor can also share in the savings realized in follow-on contracts (future acquisition) and operational costs (collateral savings). In these ways the Government is encouraging full utilization of Value Analysis techniques by all contractors, prime and sub.

In addition, many state and municipal Governments have adopted Value Analysis programs to help reduce operating expenses. Massachusetts was one of the first to initiate such a program.

Thus, the concepts and techniques of Value Analysis have spread throughout the world in both industry and Government. It has grown and been widely accepted because it gets results. It provides a modern day, organized, systematic approach to the problem of reducing costs. It can remove large amounts of unnecessary costs in your business as it has done successfully in thousands of other businesses.

Part 2. Why Unnecessary Costs

1. DEFINITION

In value engineering, unnecessary costs are defined as those costs which do not contribute to the function of the product or service.

2. DISCUSSION

It is not difficult to identify high cost areas in a product or service. In the early stages of development this is done by cost estimating techniques and in later stages by cost accounting. The difficulty has been in identifying those *portions* of the high cost areas that are *unnecessary*. The functional approach used in V.E. work provides this identification. Unnecessary costs exist in every product or service. They result from:

1. Overspecifications.
2. Excessive requirements.
3. Inclusion of "nice-to-have" features.
4. Inclusion of non-essential redundancy.
5. Over-design for expediency.

On the surface these appear to be things that could be avoided and thus we could easily avoid all the undesirable unnecessary costs. However, the problem is much more complex and concerns many human, technical and organizational aspects. Some of these will be discussed in this section to show that:

1. No one purposely inserts unnecessary costs,
2. The finger should not be pointed at any one group, and
3. An understanding of the reasons for unnecessary costs will help prevent their existence.

3. REASONS FOR UNNECESSARY COSTS

3.1 Shortage of Time

When a customer needs a product there is a rush to provide the need as quickly as possible, hopefully as soon as or earlier than the competition. Tight schedules do not permit the complete creating, searching, testing and evaluating necessary to provide the customer's requirements at the lowest possible cost. Schedule deadlines often force decisions for the purpose of expediency and result in over-designs which inadvertently include unnecessary costs.

3.2 Difficulty in Measuring of Value

Decision-making in performance-oriented work can be based upon tests and measurement. Value oriented work traditionally has been more difficult to measure. If a decision brings about poor performance, tests will show it. We have not applied tests for value to the same degree of intensity, if at all. Thus, unnecessary costs can creep in unobserved.

3.3 Difficulty in Gathering Information

3.3.1 LACK OF COMMUNICATIONS AND DATA—We, as average human beings, do not have the resources necessary to obtain all of the relevant information on a given subject. Our inability to be in more than one place at a time limits effective communication. Daily, within our Company, and often within our own building, we unknowingly duplicate effort, solve the same problems and re-invent the wheel. Even modern mechanized systems are limited in their ability to retrieve information. Decisions based on only partial data leave unnecessary cost in the product.

3.3.2 POSSIBILITY OF MISUNDERSTANDING—Communications, both verbal and written, are not free from misinterpretation. The source of many poor actions and wrong decisions trace back to original misunderstanding. "What we thought he said was not what he meant."

3.3.3 LACK OF IDEAS—The continual and expanding flow of new ideas, new materials, new products and new processes compounds the difficulty of gathering information. Lack of new ideas often forces expedient problem solutions based upon past experience or nearly related information rather than on new creative approaches. Unnecessary costs will enter into each phase of a product life cycle in which there is lack of consideration of any applicable information.

3.4 Human Factors

3.4.1 HABITS AND ATTITUDES—People have a habit of liking certain things and disliking others. They are basically creatures of habit. Their past experiences, beliefs, and traditions cause them to set up a particular habit pattern in what they think and do. If a new method is different from this pattern, an attitude of resistance is generated. Habits teach them to solve similar problems in proven ways. Attitudes perpetuate habits which cause unnecessary costs.

3.4.2 HONEST WRONG BELIEFS—People are sincere in their beliefs. Their own past experience dictates that certain things must be fact. They are reluctant to retry or reconsider an approach to a situation which was unsuccessful in their last experience.

"Don't use plastics—they're too brittle"
"You can't cast a piece that large"

Many beliefs, although honest, can be incorrect and far from the existing facts.

3.4.3 RISK OF PERSONAL LOSS—People are conservative by nature. They know that anything that is done over and over again is more sure than something new. Any decision which involves something new is a risk. In the

event of failure this could bring about personal loss to the decision-maker. Decisions, therefore, are generally made to "stick-to-channels" rather than try something new. Risk of personal loss is the basic cause of over-specification, excessive requirements and overdesign. Tolerances are tightened, margins of safety are added to requirements, redundancies are included and structures are "beefed-up." As a result costs are driven up out of proportion to the value of the product or service.

3.5 Lack of Motivation

3.5.1 LACK OF PERSONAL INTEREST—Some people have little concern for the impact their decisions have on cost. They feel that, because they are not spending their own money, the cost is not important. Pressures for meeting performance requirements on tight schedules cause individuals to avoid the cost problems.

3.5.2 LACK OF MANAGEMENT ENDORSEMENTS—Although people may not be personally interested in cost problems they can still be motivated by their superiors. But when a manager shows little interest, does not provide cost visibility and does not set a cost conscious climate, it is indicative that he does not endorse the reduction of unnecessary costs. Other indicators are:

1. Not pinpointing cost responsibility.
2. Assigning responsibility for cost as a part time job.
3. Placing the responsibility at a low level in the organization or splitting responsibility.
4. Failure to measure cost performance.

Such situations permit the existence of large amounts of unnecessary costs.

3.5.3 LACK OF ACCEPTANCE—Unnecessary cost will persist in a product or service even after considerable effort has been expended to develop a recommendation because the key decision maker is not motivated to approve the change. This happens in situations where the decision maker is in a long chain of approvals and is not motivated because he is remote from the source of motivation.

4. SUMMARY

Unnecessary costs appear in every product or service and are caused for various reasons including many human factors. Because human nature is difficult to change, these unnecessary costs persist. Value Engineering is an engineering discipline and management tool to help identify and remove unnecessary costs. It helps people to overcome or better cope with the problems of unnecessary costs by:

1. Accelerating and upgrading creative work.
2. Alerting decision makers to the functional approach to find useful alternatives.
3. Correcting misconceptions.
4. Changing habits and attitudes.
5. Providing more meaningful information for decisions on all cost matters.

Part 3. Why Value Engineering

Any job can be done better if it is approached systematically. Designing and producing products or services which present greatest value to the user is a task requiring both an organized, systematic approach and a vast amount of knowledge, creativity, and teamwork effort.

The term Value Engineering or Value Analysis identifies a systematic method which can be applied by any person who makes decisions which influence the cost of creating and producing a useful product or service. It is a creative, fact finding process which is useful in minimizing costs at all stages of a product life cycle from before-the-fact cost avoidance work to after-the-fact cost reduction work.

The concepts and techniques of value analysis are fundamental to the decision making process. Their effective use guarantees better results in finding and eliminating unnecessary costs. However, like any tool they can be misapplied and improperly used to produce poor results. Since value analysis has been proven to be a very effective method by 20 years of successful industrial application, it is usually the fault of the individual if unsatisfactory results are achieved. Value analysis is no substitute for technical and production knowledge. It is a system for making best use of this knowledge. It provides a means for the intentional, purposeful, planned, continual and extensive removal of unnecessary costs.

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SECTION II VALUE ENGINEERING

JOB PLAN AND TECHNIQUES

Part 1. Description

1. JOB PLAN

The Value Engineering Job Plan is the overall method for carrying out a value analysis study. It identifies the steps of the problem solving method. Sometimes different words are used for each phase, but the important thing is that the words cause certain behavior and actions to take place.

This workbook will use a five phase job plan as follows:

- I Information Phase
- II Creation Phase
- III Evaluation Phase
- IV Investigation Phase
- V Recommendation Phase

Some job plans include project selection and proposal implementation as part of the plan. Here they will be treated separately as adjuncts to the problem solving process. The selection of projects and the implementation of the alternative solutions are the responsibility of business management, not the problem solving process. However, since they are essential to the whole, some guidelines will be provided in these areas.

2. CHART

The following chart provides a list of all the techniques associated with the value analysis method. Each will be described more thoroughly in sections of the workbook. The columns are:

2.1 Job Plan

The steps of the problem solving method.

2.2 Functional Approach

These steps emphasize that value analysis is a functional and creative approach designed to produce a new, lower cost method of achieving the basic functional need.

2.3 Objectives

This column indicates the primary end objectives which each phase of the job plan should accomplish.

2.4 Key Questions

These are key questions which must be answered in each phase. They are often simplified to:

- What is it?
- What does it cost?
- What does it do?
- What else will do the job?
- What will that cost?

2.5 Specific Techniques

These are words used to identify the techniques that should be applied in carrying out each phase of the job plan. An attempt has been made to place them in order of most common usage. However, value analysis is often a cyclical process and each tool or technique is used repeatedly and at the most desirable times in the analytical process.

2.6 General Techniques

Some techniques must be employed throughout the entire job plan. These are general guidelines for effective value work and it is important to employ them if good results are to be achieved.

NOTES

Part 2. Chart of Techniques

JOB PLAN	FUNCTIONAL APPROACH	OBJECTIVES	KEY QUESTIONS	SPECIFIC TECHNIQUES	GENERAL TECHNIQUES
Information Phase	Define and evaluate functions	Obtain background information Define and evaluate functional requirements	What is it? What does it cost? What does it do? What must it do? What is the value of the function?	Get all the facts Determine costs Analyze costs Put a \$ on specs and requirements Examine and question all specs and requirements Define functions Evaluate functions Analyze functions	Work on specifics Get information from the best source
Creation Phase	Create alternatives	Create new ideas	What else will do the job?	Blast and create Apply creative techniques Defer judgement	Use teamwork
Evaluation Phase	Evaluate alternatives	Select the best ideas	What are the best ideas? What will these ideas cost?	Refine ideas Put a \$ on each idea Evaluate ideas	Use good business judgement
Investigation Phase	Develop alternatives	Select the best alternative	What is the best alternative? What will this alternative cost?	Use search techniques Consider alternate products, processes and materials Consider standards Consult suppliers Consult company and industrial specialists Compare costs	Overcome roadblocks Use good human relations
Recommendation Phase	Recommend alternatives	Document the best alternative	How should this alternative be presented?	Use one page recommendation form Motivate positive action	

NOTES

Part 3. General Techniques

The general techniques of value engineering are aimed at helping people to overcome certain human weaknesses prevalent in everyone. They are reminders in the field of human behavior and are of significant importance in the areas of decision making and problem solving because failure to practice one of these techniques may result in an unsuccessful value study. They are defined briefly here as a reminder that they should be used throughout any value work.

- Work on Specifics (not generalities).

Aim your value analysis at a specific part or area. Select each item for an intense, directed study concentrating on it until a factual, specific proposal or alternative approach is developed. Proposals of a general nature are easily roadblocked, but a proposal on a specific part, backed up by facts, is irrefutable. Concentrate value engineering work on specific projects and present specific proposals. A general suggestion to "use diecastings" would not generate any action, but a specific proposal to replace a certain machined part with a die cast part listing detailed factual advantages in cost, performance, schedule and appearance would more likely motivate positive action.

- Get Information From the Best Source.

Everyone is ready to give advice when asked, but not everyone has the *right* information. There are two basic principles in this technique area. First is to seek information from multiple sources, and second, to seek the best source for the information desired. It is human nature to think that we can do anything as well as the other fellow and to admit we cannot is a sign of weakness. Such a philosophy, however, can result in one being a "design hermit" who continually attempts to "re-invent the wheel." In today's world of specialization, no one is an "island unto himself." The best ideas and solutions come when the latest most accurate information is sought from the best sources. Be sure you are up to the "state-of-the-art" before you do it yourself, and when seeking advice ask the person most qualified to give it—the specialist.

- Use Teamwork.

A fundamental principle of value work is to employ teamwork. In the modern complex business enterprise with many different functions and people contributing to product value, it is essential that they blend their talents toward common objectives. A football team would get nowhere if each player did not do his part toward reaching a common goal. The problem is that modern life teaches competition, and decisions are often influenced by what is best for the individual, not what is good for the company. Value work requires cooperative effort on the part of many people whose decisions affect cost. Effective teamwork is coordinated individual effort, not group or committee work. Value analysis requires concentrated individual effort but the results can be magnified several times with teamwork. See Section III for more on teamwork.

- Use Good Business Judgment.

Often this technique is called "use your own judgment" or "spend the company's money as you would your own."

In any case, it is all related to using good judgment. Man has been endowed with the capability to apply common sense and good judgment to his actions. However, often his environment influences his ability in this area. Studies made in industry have shown that 70% of the people do things the way they think they ought to be done less than half the time. Thus, the majority of business people are performing in a way contrary to their good judgment more than half the time. In value analysis we should employ the philosophy "if it doesn't seem right it probably isn't" or "if I wouldn't spend my money for it, it's probably too expensive." Value analysis should have the courage of their convictions and take action to change things that their good judgment tells them are wrong.

- Overcome Roadblocks.

Roadblocks are obstacles in the path of progress. Whenever one attempts to make improvements or change a way of doing things he encounters "roadblocks." Some are real and some are imaginary. All value analysis techniques help "overcome roadblocks," but we should recognize their existence and be prepared to act in a certain way when they are encountered. First, question the validity of the roadblock. Is it based on fact or opinion? Second, analyse the roadblock to ascertain what is needed to overcome or circumvent it. A solid fact from an authoritative source will do the job. Often habits and attitudes are the basis for a roadblock. Statements such as: "We've never done it that way" or "It's not our policy" or "It won't work" fall into this category. A careful analysis will classify the roadblock and guide one to obtaining the facts necessary to remove the obstacle.

- Use Good Human Relations.

The human factors and relations problems are crucial to improvements and changes. Since value work is concerned with change, it is concerned with human relations. The importance of human relations varies directly with how much you must depend on other people. In value analysis there is a high degree of dependence on other people and thus good or poor human relations can mean success or failure. Some of the areas where good human relations must be employed are:

- In fact finding—getting good information from people requires their cooperation.
- In creativity—good ideas come from people who are properly motivated.
- In implementation—receptivity to ideas has to be generated.

Some general guidelines for good human relations in value analysis work are:

- Treat people fairly and honestly.
- Give credit.
- Be consistent—let people know what to expect of you.
- Act in ways which avoid personal loss or embarrassment.
- Be a good listener.

NOTES

SECTION III VALUE ENGINEERING STUDIES

Part 1. Selection of Value Engineering Projects

A value engineering project is the item to be studied. It can vary from a system or equipment to a small part or component. It can also be a software item such as a procedure, process or circuit diagram. One would first consider the various systems, equipments, products that are available, and then review the elements of the system. The final selection of a suitable value engineering project is the result of this "boiling down" process.

In selecting projects, there are a couple of general guidelines:

- Work where the money is.
- Work where the profits are low.

When considering the application of value engineering to new products, one would consider many criteria such as:

- Is the new product similar to old designs?
- Is there ample production?
- Is competition intense?
- Is total cost important to the customer?
- Does the customer require value engineering?
- Is it a fixed price or incentive contract?
- Is the profit potential good?
- Is the design time tight?
- Have the performance or technical problems been largely solved?

On existing products one might ask additional or different questions such as:

- Are changes feasible?
- Are profits low?
- Is competition pressing?
- Does the customer measure value engineering performance?

- Is there a value engineering incentive clause?
- Are the future business prospects good?

In the selection of specific projects within products one would look carefully at the design history, the cost situation and the manufacturing or source situation and ask questions such as:

- Are sufficient dollars to be spent on the item to result in a savings which would offset the cost of the study and implementation?
- Is the cost out of line for the function performed?
- Are there production or procurement problems?
- Is it a single source item?
- Has it always been made or bought?
- Has the same vendor been used for a long time?
- Has the same process, material, method or machine been used for some time?
- Has it been some time since redesign?
- Is it a custom design?
- Are cost elements unreasonable?

If the answer is yes to one or more of the above questions, it may be desirable and profitable to conduct a value engineering study. Other questions would be whether or not a design team, design reviews, value engineering, or cost target concepts were previously applied during design.

Once an area or product or assembly has been selected, certain cost and functional analysis techniques may be applied to pinpoint more specific areas for value engineering work (see Section IX). For training purposes projects should not be too complex and should have good educational potential.

Part 2. The Team Approach

It has been mentioned previously, under "teamwork", a general technique, that coordinated effort of various people with different knowledge can magnify the effectiveness of value analysis. This statement requires amplification and the definition of specific guidelines otherwise team effort may degenerate into a loose committee approach which will slow down progress and depreciate results.

In value engineering workshop training seminars, it has been customary to teach value analysis techniques using a "tell-show-do" concept which:

- Describes the techniques by lecture.
- Shows the application by example.
- Reinforces the learning by practice.

In the practice or workshop section, a team approach is used. From three to six people are assigned a value analysis project consisting of a part of a product currently in design or production. The team members are from several functions such as engineering, manufacturing, purchasing, financial, marketing, etc. and have a range of formal education, training and experience. This brings together a broad knowledge base to work on the problem. Such an approach can shorten the fact finding time, add to the creative effort and generate a better solution—*IF* the group works together as a team. To do so takes organization and leader-

ship. Each member must carry his share of the load, do his part. Since each person should be a responsible decision maker, he should have certain talents. The team leader should determine these talents and allocate tasks which make optimum use of each member's skills.

In each phase of the job plan the team should carry out both individual and group actions so that each step and technique gets accomplished in the most productive and efficient way. One member can obtain and organize costs, one analyse the specifications and identify problem areas, one can get the purchasing information, etc. Each can summarize and document the information so that the team can plan, create, and act to solve the problem. The leader must see to it that each person is active and contributing.

In a training program, it may be desirable to have two people carrying out tasks together as part of the learning process, an inexperienced member working with someone skilled in the technique. In any case the above guidelines should be employed whether in a seminar or a task force value analysis study. In addition to gaining experience in the techniques and learning by trial and error, the members learn teamwork and integrated action, an important aspect of daily business activity. Furthermore, they learn a respect for the potential contribution of other people in problem solving, and develop a common value consciousness and improved communication.

SECTION IV PHASE I OF THE VALUE ENGINEERING JOB PLAN

Part 1. Description of Information Phase

1. THE OBJECTIVES OF THIS PHASE ARE:

- 1.1 Identify the problem.
- 1.2 Obtain all the facts.
- 1.3 Define and evaluate the functions.

2. THE TECHNIQUES USED IN THIS PHASE ARE:

2.1 Get all the facts.

- 2.1.1 RECORD MARKETING AND CONTRACTUAL INFORMATION.
- 2.1.2 RECORD ENGINEERING INFORMATION.
- 2.1.3 RECORD MANUFACTURING INFORMATION.
- 2.1.4 RECORD PURCHASING INFORMATION.

2.2 Determine costs.

- 2.2.1 LIST COMPONENTS.
- 2.2.2 LIST COST ELEMENTS.
- 2.2.3 ANALYSE COSTS.

2.3 Put \$ on specifications and requirements.

- 2.3.1 IDENTIFY CRITICAL SPECIFICATIONS, REQUIREMENTS, AND TOLERANCES.
- 2.3.2 INDICATE ASSOCIATED COSTS.
- 2.3.3 EXAMINE AND QUESTION ALL SPECS AND REQUIREMENTS.

2.4 Define functions.

- 2.4.1 DEFINE THE BASIC FUNCTION OF THE UNIT UNDER STUDY.
- 2.4.2 DEFINE THE FUNCTIONS OF ALL COMPONENTS.
- 2.4.3 IDENTIFY BASIC AND SECOND DEGREE FUNCTIONS.

2.5 Evaluate the functions.

- 2.5.1 ESTABLISH A VALUE FOR THE BASIC FUNCTION(S).
- 2.5.2 IDENTIFY THE BASIS OF EVALUATION.
- 2.5.3 ANALYSE FUNCTIONS.

3. DISCUSSION.

This phase is a fact finding and questioning process. You seek out and record all background information in the Marketing, Engineering, Manufacturing and Purchasing areas. By a thorough review of all documented data and by questioning the most knowledgeable people from each area, all the significant facts concerning the item under study are obtained. A functional approach is used to clarify the essential functional requirements and establish their worth to highlight unnecessary cost areas and ascertain the potential value improvement.

4. DESCRIPTION OF TECHNIQUES.

4.1 Get all the facts.

4.1.1 Obtain the orientation and contractual information identified in section 1.1 of the Information Phase worksheet from marketing, program or contracts areas. Record on worksheet.

4.1.2 Obtain the engineering background information identified in section 1.2 of the worksheet from engineering documents, specifications and personal contact with the cognizant engineers. Record.

4.1.3 Obtain the manufacturing information identified in section 1.3 of the worksheet from manufacturing documents, (method sheets, tool and process drawings, inspection and test instructions, scrap and rework data, etc.) and personal contact with responsible manufacturing personnel. Record.

4.1.4 Obtain the purchasing information identified in section 1.4 of the worksheet from purchasing records and personal contact with the responsible purchasing personnel. Record.

4.2 Determine costs.

(back of information worksheet).

4.2.1 List all the components or parts of the assembly or unit under study. If the unit consists of several subassemblies or parts these should be grouped by functional areas, major parts or top-to-bottom (generation) breakdown. The "level" column can be checked to indicate level of assembly (what parts go into the next higher assembly level). Depending on the type of project (unit under study) the space on this worksheet can be used in different ways. Usually the analysis is started with a system or assembly and worked down to parts. Additional sheets may be required. The quantity/unit column should indicate how many of each part are used in the unit under study.

4.2.2 The columns in the 2.2 section are for listing all the costs. The /item column is for the cost of each item listed in 2.1 column. The /unit column is the product of quant/unit and /item columns. The next series of columns provide space for a breakdown of the cost/item into material costs, fabrication and assembly labor costs, inspection and test costs. All costs should be adjusted to product cost level by factoring bare labor and material costs up by the cost factors listed at the bottom of this worksheet. These factors can be obtained from the cost department. Unit costs should be totaled and recorded at the bottom of column 2.2 (See Section IX, 1.1.4 for further description.)

4.2.3 ANALYSE COSTS—The cost data listed in 2.2 columns should be analysed by various techniques. Additional worksheets may be required. For further information see Cost Analysis Techniques under Section IX.

1. Circle the high dollar cost/item, and cost/unit figures. It may be desirable to list major cost items in order (high cost downward).

2. Circle the cost elements (material, fab, test, etc.) that appear to be of major importance or out-of-line. Further analysis of these items may be in order to determine the specific cost increments of the process or method which contribute most to the cost.

3. In some cases cost/pound, cost/function, cost/dimension or other cost analysis techniques may lead to the identification of the problem and unnecessary costs.

4.3 Put a \$ on specifications and requirements.

4.3.1 Review all specifications, requirements and tolerances to identify those that are critical or most important. See Section IX, 1.2.5 for further discussion.

4.3.2 Determine the costs that these specifications, requirements or tolerances add to the product or item under study. Identify those that contribute significantly to the cost by estimating or measuring the cost incurred. Record a brief description of the requirement and the associated cost in Section 3 at the bottom left, back of the worksheet.

4.3.3 Examine each requirement (customer and company) to ascertain whether it is essential to the satisfactory functional performance of the product or item. Question the need for the requirement. This technique is aimed at the identification and elimination of over-specification. In this phase the costly specifications are identified. After functional analysis it may be determined that a change, modification or elimination of the requirement may be made to reduce cost and still maintain desirable performance.

4.4 Define Functions.

4.4.1 The first step in the definition of functions is to determine the basic function for the unit under study. The basic function is the prime, specific purpose for the unit; its main reason for existence. It is possible the unit may have more than one basic function. Functions can be described in two words—a verb and a noun—such as conduct current, support weight, insulate voltage. The best way to determine the basic function is to write down a list of verb-noun definitions and then select the one or more which seem to most clearly define the primary purpose for the unit under study. These definitions are put in section 4.1 in the upper right of the worksheet. Under the function definition, quantify the function, i.e., define the amount of the function which must be performed such as number of pounds supported, etc. See explanation notes.

4.4.2 The second step is the definition of the functions of all the components listed in column 2.1. This is done by listing the verb-noun definition for each subassembly and part in columns 4.2.

4.4.3 The third step is to identify the basic and secondary functions. Secondary functions are those that do not contribute directly to the achievement of the basic function. This is done by comparing the verb-noun definition of each

component function with the basic function(s) listed at the top of the worksheet. Those that are similar or contribute directly in whole or in part (in complex functions such as electronic circuits several components may contribute) to the basic function are identified by a check in the "basic" column of 4.3. All others are checked in the "secondary" column of 4.3.

Explanatory Notes.

There are two kinds of functions which occur in most products—those which make the product "work" (perform its intended job), and those which make it "sell" (cause people to buy one product rather than another). Both are important in a competitive market. Although the basic function of the overall product may be a "work" function, "sell" functions may be essential secondary functions and should be value analyzed as a separate area (unit under study).

Secondary functions may be essential or non-essential. That is, they could be required to make the selected design concept work or they could be superfluous. It is sometimes difficult to categorize basic, essential secondary and non-essential secondary functions, but the analysis often reveals areas which can be combined, simplified or eliminated. Secondary functions can be classified into essential and non-essential by putting an "E" or an "N" in the blocks checked in column 4.3.

The type of verbs and nouns used can be significant to the functional analysis. Functions can be defined in general terms (high level of abstraction) such as a pencil may "communicate messages," "record data," etc. or it could be defined in more specific terms (low level of abstraction) such as "make marks." It may be advantageous to define functions in several ways for both analytical and creative purposes.

The type of noun used can be significant for evaluation purposes. For instance, some nouns are more mathematically measurable such as weight, torque, current, voltage, etc. than others such as table, component, appearance, connection, etc. Again it may be advantageous to define functions using both measurable and non-measurable nouns.

Functions should not be confused with constraints or conditions under which the function is performed. The function is *what* should be done. The constraints quantify and qualify *how* it should be done. For instance, a chassis' function would be "support weight." The constraints would be: amount of weight, volume or size, method of support, corrosion resistance, environment, safety factor, form or shape, appearance, etc. The major constraint would be the amount of weight. It is important to quantify the major constraint before evaluating functions.

4.5 Evaluate functions

4.5.1 FUNCTIONS ARE EVALUATED BY COMPARISON—Since the customer or user is primarily interested in the achievement of basic functions, not secondary functions, it is only the basic functions which will be evaluated. In this technique, value is being measured by an attempt to place a worth on the function. Thus, the value of the basic function is what the user should pay

for the achievement of that function. The "value" may have no relationship to the cost of the present unit or component. Value levels may be based on unit costs or life cycle costs.

Functions are evaluated by comparing the relative costs of alternate methods of performing the function. Standard or commercial products, common materials, mass produced items and basic materials can be used as a basis of comparison considering the amount of the major constraint. It is often desirable to make several comparisons. An attempt is made to find the lowest cost to perform the basic function.

Comparison can be made on the basis of shape, form, weight, size, color, material, complexity, and function. What other devices have the same general use? What other devices accomplish the same function? What other materials would accomplish the same function? How much material is necessary to perform this function? What would this material cost? What are the lowest cost commercial components which would perform the same function? How much would they cost? The objective is to establish a value level which minimizes or totally eliminates all secondary or unnecessary costs. Thus, the value becomes the target of perfection. The cost-quantity curve (see figure 1) of a good value product should be an asymptote of the value line. Note that the quantity produced will affect the cost and the cost/value ratio.

The objective of Value Engineering is to reduce unnecessary and secondary costs to lower the cost curve.

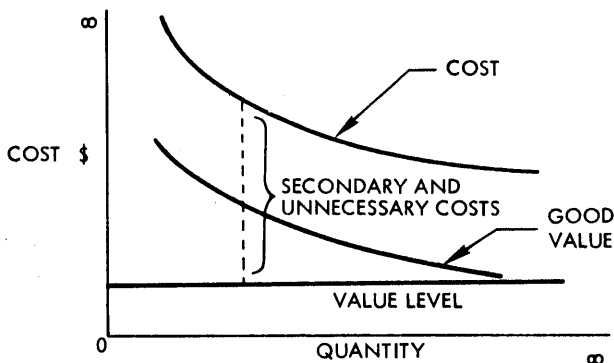


Figure 1.

The value level may vary depending on the method of comparison. The basic material method gives the lowest level. For example the amount of steel necessary to "support-weight," the amount of lead in a pencil needed to "make marks," etc.

These functional values are recorded in column 5.1 and totaled at the bottom of the column.

4.5.2 Identify the methods, parts, products, materials or forms which were used as a basis of evaluation of the basic function. Record opposite each value in column 5.2.

4.5.3 ANALYSE FUNCTIONS—Using the information recorded on the back of the Information Worksheet, a number of functional analyses can be made to identify unnecessary cost areas. For further information see Section IX.

Establish the cost/value ratio by taking the total cost of the unit under study (column 2.2) and dividing by the total

value. Record in space 5.3 as 10/1, 20/1, etc. This ratio is an index of the value level and a measure of the potential improvement. High ratios indicate poor value. Where secondary functions have been determined to be essential it may be desirable to use this technique to pinpoint poor value.

Analysis of functional areas is another technique. Here the unit under study is divided into functional areas such as mechanical, electrical, fastening, appearance, protection, etc. Costs and values are established to determine where costs seem to be out of line or unnecessarily high. A functional tree chart or block diagram of functional areas, with components arranged from high cost to low cost, provides an excellent tool for visual analysis of system costs.

Analysis of similar functions may show a potential for simplification or the elimination of duplication. For example, it may be found that several parts all perform the same function, or that there are more costs associated with secondary functions than the basic function.

As a result of these analyses a determination should be made regarding disposition of the project. It may be decided that: the whole project should be continued; certain component areas warrant further study; or good value exists and no worthwhile savings could be achieved. A place is provided at the bottom right back of the worksheet (5.4) for notes regarding disposition or items selected for further study or subprojects.

Explanatory Notes.

The objective of the cost and functional analyses is to highlight unnecessary costs and establish cost targets for improved value. The effort should be directed to minimize costs and cost/value ratios.

The techniques of defining and evaluating functions are not easy, and there are many refinements to the techniques. However, it is an excellent motivational device which:

- clarifies the problem
- forces a new approach,
- separates functions from constraints,
- improves creative opportunities, and
- establishes a measure of value.

Throughout the functional approach keep in mind that value in a product is maximum when performance is reliably achieved for minimum total cost. Thus satisfactory performance throughout the desired life cycle of the product is essential to good value. Consequently, total costs, not only procurement or manufacturing costs, are important. With this in mind value analysis studies often lead to improvements in life cycle costs, reliability, maintainability, producibility, schedule, warranty, service, weight, and other factors. When making comparisons of alternate approaches, it is desirable to factor in all costs to the user for the life of the equipment such as: price, installation, repair, service, operating, spare parts, etc. Moreover, all cost factors, recurring and non-recurring, should be considered so that the true impact of the change will be anticipated.

5. SUMMARY.

In the information phase, the following key questions should be answered.

1. What is it?
2. What does it cost?
3. What does it or must it do?
4. What is the value of the function?

The worksheet and these guidelines are designed to help the analyst. Additional sheets may be essential depending on the complexity of the unit under study. For simple parts the techniques may be carried out in a straightforward manner. In complex assemblies or systems it may be necessary to divide the unit into several subprojects which are identified by some of the more complex cost and functional analyses. When the specific areas for further study are determined and the problem well defined, the analyst should proceed to the next phase of the job plan, the creative phase.

Part 2. Check List – Information Phase

	NO	YES
MARKETING & CONTRACTUAL		
Has all the orientation and contractual information been obtained? (See worksheet)		
Have the customer specifications and requirements been reviewed?		
Are the specifications realistic?		
Are all performance and environmental requirements necessary and sufficient?		
Would a modification of the specifications simplify the design and manufacture of the product?		
Are all specifications required by the contract or are they only guidelines?		
Have the specifications been interpreted correctly?		
Has the future marketing and sales position been determined?		
Have field or service personnel been contacted to identify problems contributing to high cost or poor performance?		
ENGINEERING		
Has all the engineering background information been obtained? (See worksheet)		
Does the design do more than the specification requires?		
Have all the severe and special environment, performance and operating requirements been identified?		
Are there any difficult requirements for installation, maintenance, testing, safety, weight, size?		
Have the original designers and the date of the last design been determined?		
Are any special, hard-to-get or costly materials or components specified?		
Are all the constraints under which the product is designed, manufactured and operated realistic and reasonable?		
Have all the functions been defined, evaluated and analysed?		
MANUFACTURING		
Has all the manufacturing information been obtained? (See worksheet)		
Are there any particularly costly, time consuming, or wasteful methods, processes or operations employed?		
Is the tooling and set-up more costly than necessary?		
Are there any special inspection, test, material handling, packaging or shipping problems which are more costly than necessary?		
Are there any tolerances or other technical requirements which cause manufacturing problems?		
Have all the manufacturing costs been determined?		
Have all the cost increments and elements been examined and analysed?		
PURCHASING		
Has all the purchasing information been obtained? (See worksheet)		
Has the buyer been contacted to discuss purchasing problems and information?		
Have the present vendors (suppliers) been interviewed to ascertain any problems which contribute to high costs?		
Have the parts history (purchasing) folder been examined to obtain background information?		
Does the supplier or subcontractor have a value engineering program or clause in his contract?		
Have there been any price, delivery, or quality problems?		
GENERAL		
Have all the high and unnecessary cost areas and high cost/value ratio areas been identified?		
Have all the best areas for potential value improvement been selected?		
Have the key problems been well defined?		
Have the essential constraints been well established and clearly defined?		
Are the functional requirements well understood?		
Does the dollars expended or potential cost reduction (net savings) appear to be sufficient to make further investigation and project development worthwhile?		

It is desirable to obtain affirmative answers to as many of these questions as possible before proceeding to the next phase of the job plan.

NOTES

VALUE ENGINEERING

SEMINAR NUMBER _____
PROJECT NUMBER _____
PAGE NUMBER OF _____
DATE _____

PROJECT LEADER _____ LOC. _____ EXT. _____
SECRETARY _____ LOC. _____ EXT. _____
TEAM SPEAKER _____ LOC. _____ EXT. _____

INFORMATION PHASE WORKSHEET

TEAM INFORMATION	1.2 ENGINEERING INFORMATION	1.3 MANUFACTURING INFORMATION	1.4 PURCHASING INFORMATION
<p>Team Members _____ Loc. _____ Ext. _____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p>What is it? _____</p> <p>_____</p> <p>What does it do? _____</p> <p>_____</p> <p>Applicable Specifications _____</p> <p>_____</p> <p>Requirements: _____</p> <p>Humidity _____</p> <p>Vibration _____</p> <p>Shock _____</p> <p>Corrosion _____</p> <p>Altitude _____</p> <p>Life _____ Years</p> <p>Reliability _____ MTBF</p> <p>Temperature _____</p> <p>Other _____</p> <p>Engineering Problems: _____</p> <p>_____</p> <p>Anticipated Changes: _____</p> <p>_____</p> <p>Suggestions: _____</p> <p>_____</p> <p>Person(s) Contacted: _____</p> <p>_____</p> <p>_____</p>	<p>Production Rate _____ /Mo. _____ /Yr.</p> <p>From _____ To _____</p> <p>Description of Manufacturing Process: _____</p> <p>_____</p> <p>Requirements: _____</p> <p>Tooling _____</p> <p>Inspection _____</p> <p>Test _____</p> <p>Pack & Ship _____</p> <p>Manufacturing Problems: _____</p> <p>Process _____</p> <p>Fabrication _____</p> <p>Assembly _____</p> <p>Test _____</p> <p>Rework _____</p> <p>Scrap _____</p> <p>Delivery _____</p> <p>Other _____</p> <p>_____</p> <p>Anticipated changes: _____</p> <p>_____</p> <p>Suggestions: _____</p> <p>_____</p> <p>Person(s) Contacted: _____</p> <p>_____</p> <p>_____</p>	<p>Present vendor(s): _____</p> <p>_____</p> <p>Additional vendors: _____</p> <p>_____</p> <p>It this a single source item? _____</p> <p>How many approved sources are there? _____</p> <p>_____</p> <p>Does present vendor have Value Engineering? _____</p> <p>_____</p> <p>Has vendors aid been solicited? _____</p> <p>Vendors suggestions: _____</p> <p>_____</p> <p>_____</p> <p>Purchasing Problems: _____</p> <p>_____</p> <p>Anticipated Changes: _____</p> <p>_____</p> <p>Suggestions: _____</p> <p>_____</p> <p>Person(s) Contacted: _____</p> <p>_____</p> <p>_____</p>
<p><u>1.1 ORIENTATION INFORMATION</u></p> <p>Customer _____</p> <p>Program _____</p> <p>Contract Number _____</p> <p>Contract Period _____ To _____</p> <p>Equipment _____</p> <p>Dwg. Number _____</p> <p>Quantity/Contract _____</p> <p>Unit Under Study _____</p> <p>Drawing Number _____</p> <p>Quantity/Equipment _____</p> <p>_____</p> <p><u>CONTRACT INFORMATION</u></p> <p>Type of Contract _____</p> <p>Type of VE Clause _____</p> <p>Future Qty. (Unit Under Study) _____</p> <p>_____ /year. For _____ Years.</p> <p>Spares Qty. (Unit Under Study) _____</p> <p>Also Used on _____</p> <p>Person(s) Contacted: _____</p> <p>_____</p> <p>_____</p>			

SECTION V PHASE II OF THE VALUE ENGINEERING JOB PLAN

Part 1. Description of Creation Phase

1. THE OBJECTIVE OF THIS PHASE IS:

1.1 To create new ideas on ways to perform the function(s)

2. THE TECHNIQUES USED IN THIS PHASE ARE:

2.1 Blast and Create.

2.2 Apply Creative Techniques.

2.2.1 INDIVIDUAL IDEATION TECHNIQUES.

2.2.1.1 Search Publications.

2.2.1.2 Use Check Lists.

2.2.1.3 Develop Idea Matrices.

2.2.2 GROUP IDEATION TECHNIQUES.

2.2.2.1 Discussion Method.

2.2.2.2 Brainstorming.

2.3 Defer Judgement.

3. DISCUSSION.

This phase is designed to generate a large number of alternatives to meet the functional requirements identified and defined in the Information Phase.

To do this, one or more creative techniques are used to produce all possible methods, configurations, materials, processes and other means by which the basic function might be performed.

Creative techniques assist the idea generating ability of people by helping them to think of a larger number of better solutions to a problem. They are inventive processes which should be applied by both individuals and groups. Group efforts have the advantage of the pooling of diversified knowledge and exposure to different viewpoints on a problem. They stimulate each individual to think of more ideas. In this phase we are attempting to answer the question of "What else will do the job?"

4. DESCRIPTION OF TECHNIQUES.

4.1 Blast and Create.

This term describes the basic philosophy of the creative process used in value engineering. "Blast" means to remove from our thoughts any preconceived solutions to the problem. We attempt to forget the existing method or configuration and, instead, think in terms of the functional requirements. "Create" means that we generate a large number of alternative ideas which might perform the function. By this "Blast and Create" process a vastly improved method may be conceived instead of a minor modification to an existing method or piece of hardware.

The first step is place the verb-noun definition of the basic function from the information worksheet in the space

provided on the Creation Phase worksheet. Separate worksheets should be used for each basic function.

4.2 Apply creative techniques.

The second step is to apply one or more creative techniques which stimulate the production of ideas. Some of these are applicable for individual effort and others are for group participation. In either case, the objective of this step is to list on the worksheet alternative ways in which this function may be performed. It is desirable to record at least 25 ideas on each worksheet. The following sections describe some of the idea generating techniques which may be used.

4.2.1 INDIVIDUAL IDEATION TECHNIQUES.

4.2.1.1 Search publications. Read periodicals, technical papers, trade magazines, directories, and catalogs. Creative ideas are formed by reorganization and recombination of existing knowledge. A constant awareness of existing skills and new technical advances will broaden one's ability to think up new approaches. It is helpful to maintain a notebook or file of new or unusual devices.

4.2.1.2 Use check lists. Various forms of listings can be developed as a tool for stimulating creative thinking. An "idea needler" list is helpful. For example: What would happen if an idea was magnified? reversed? rearranged? minified? put to a different use? adapted? combined with another idea? The alphabet is a good check list. Try to think of all the methods starting with each letter. Another type of listing which is helpful is called an "attribute list." Here you make a list of the characteristics (attributes) of the item or object. For example, a screwdriver has a round handle, plastic handle, steel shank, square shaped, etc. Each attribute is considered in turn and changed in all conceivable ways often resulting in a brand new approach to the problem. Thus this handle could be square, hexagonal, flat or made of wood, metal, cork, etc.

4.2.1.3 Develop idea matrices. A large number of ideas can be developed rapidly by using a matrix. Column headings of desired parameters are listed across the top of a sheet. Variables of each parameter are listed under the columns. By combining each variable in each column with each other variable, a large number of different approaches are available. For example, five columns with five variations of each permits 3125 possible combinations.

For example, if creating on the function of "control flow" (a valve) we might set up a matrix with five columns headed as follows.

Type	Body	Fabrication	Actuation	Sealing
Gate	Brass	Cast	Manual	Leather
Globe	Steel	Forge	Electric	Rubber
Needle	Copper	Draw	Hydraulic	Felt
Poppet	Aluminum	Machine	Pneumatic	Metallic
Spool	Plastic	Mold	Mechanical	Plastic

Thus, we could have a Gate valve of plastic molding, pneumatically operated with rubber seals and 3124 other combinations which would stimulate thinking and lead to a new method of controlling flow.

Another variation of this technique would be to create lists of all possible variables of design configurations, materials, products, processes and manufacturing sources and then generate new ideas by combining different variables from each list.

4.2.2 GROUP IDEATION TECHNIQUES.

Individual creative efforts can often be greatly enhanced by various group techniques. Experimentation in creativity has shown that when two or more people combine their knowledge and concentrate on solving one problem, the results are increased several times. This is due to the catalytic action that takes place when one idea stimulates another. There are a large number of different techniques to make use of group brainpower but for value engineering purposes we will boil them down to two: Discussion and Brainstorming.

4.2.2.1 Discussion Method.

Two or more people discuss the functional problem in an informal way. The problem definition should be discussed to express it in different ways, verb-noun, different words, different levels of abstraction. The constraints or other requirements should be identified and discussed. Then various possible solutions are discussed. By verbally stating the problem and by discussing the problem with other people new ideas are triggered. The discussion should be directed in a progressive, positive thinking way, otherwise it may get "bogged" down by argumentative negative discussions. In larger groups it may be desirable to have a leader designated to define the problem clearly in a creative manner, (such as "How many ways might?") develop attention, maintain interest and stimulate participation. In this technique it may be advantageous to identify the problem risks, disadvantages and advantages of each idea as a means of promoting discussion and leading to new ideas. The most effective groups are made up of people with different backgrounds but of the same organizational level. Someone should be designated to keep notes or a tape recording should be made of the session so that good ideas are recorded. Summarize the ideas on the Creative worksheet.

4.2.2.2 Brainstorming.

This technique is different from the "discussion" method in that all discussion of ideas is deferred to a later time.

It is used to generate a large number of ideas in the shortest time on the thesis that quantity of ideas breeds quality or the more ideas the better the chance of getting a good, new idea. Usually from 6 to 12 people make a good "brainstorm" group although this technique can be used with more or less people. The problem is stated in broad functional terms in the first session to stimulate the greatest innovation (new approaches). In later sessions it may be desirable to narrow the problem definition to get more specific solutions and meet all the constraints; but it is desirable not to be inhibited by the constraints too early in the Creative process. After problem definition the group verbally calls out all ideas that come to mind. All ideas should be recorded, sometimes visually for the group, sometimes by secretary or tape. It may be advantageous to use different methods of recording, but be sure to record. The rules of brainstorming should be clarified with the group at the start of the session. They are:

- Criticism is ruled out. (Judgement is deferred until a later session.)
- The wilder the ideas, the better. (They "trigger" other ideas.)
- Quantity is wanted. (The more ideas, the more possible winners.)
- Combination and improvement is sought. ("Hitch-hike" on ideas of others.)

4.3 Defer Judgement.

An underlying principle which should be used throughout this phase of the job plan is highlighted by this technique. That is: "ideas are not judged or evaluated" even in the discussion method, although problems may be discussed, it is desirable to postpone judgement on any idea, and concentrate on the generation of ideas. All ideas are evaluated in the next phase. Premature judgement may kill a potentially good idea. Often ideas which appear unworkable can be developed into a usable, better method.

5. SUMMARY.

The Creative Phase worksheet should be used to record all ideas developed from any of the creative techniques. There is a space for the verb-noun functional or problem definition. A new worksheet should be used for each definition. At least 25 ideas should be generated on each worksheet.

The purpose of this phase is to apply one or more techniques to stimulate creative behavior. In this phase we "create" ideas in quantity and purposely defer judgement for feasibility. An incubation period to allow for addition and expansion of ideas is highly desirable before proceeding into the next phase of the V.E. Job Plan (The Evaluation Phase) in which the ideas are analyzed, refined and evaluated. It is also advantageous to use some of these creative techniques in later phases of the Job Plan.

Part 2. Check List – Creation Phase

	NO	YES
Have all basic functions been identified for this project?		
Have all basic functions been defined by a verb-noun description?		
Is a separate Creation Phase worksheet available to be filled out for each basic function description?		
Has the basic function verb-noun description been entered into the space provided on each Creation Phase worksheet?		
Has one or more creative techniques been chosen as a method to generate alternative ideas?		
Have you dismissed from your thoughts the present way the basic function is accomplished?		
If group ideation techniques are to be applied has the group been made aware of the concept of blasting the present method from their thoughts?		
For group ideation, has the techniques, method of approach, and "ground rules" been explained before proceeding?		
As a result of applying creative techniques have a number (25 or more) ideas been generated?		
Have the ideas been documented?		
Has judgment been deferred and all ideas listed regardless of their potential?		
Have you provided for a sufficient incubation period to permit later addition of more ideas?		
Have you made provisions for a later follow-up session to evaluate and refine the ideas?		
Have all of the basic functions on the project been subjected separately to the complete Creation Phase?		

It is desirable to obtain affirmative answers to as many of these questions as possible before proceeding to the next phase of the job plan.

NOTES

VALUE ENGINEERING

SEMINAR NUMBER

PROJECT NUMBER

PAGE NUMBER OF

DATE

CREATION PHASE WORKSHEET

The basic function

Verb

Noun

1.	30.
2.	31.
3.	32.
4.	33.
5.	34.
6.	35.
7.	36.
8.	37.
9.	38.
10.	39.
11.	40.
12.	41.
13.	42.
14.	43.
15.	44.
16.	45.
17.	46.
18.	47.
19.	48.
20.	49.
21.	50.
22.	51.
23.	52.
24.	53.
25.	54.
26.	55.
27.	56.
28.	57.
29.	58.

SECTION VI PHASE III OF THE VALUE ENGINEERING JOB PLAN

Part 1. Description of Evaluation Phase

1. THE OBJECTIVE OF THIS PHASE IS:

1.1 To select the best ideas.

2. THE TECHNIQUES USED IN THIS PHASE ARE:

2.1 Refine ideas.

2.1.1 ARRANGE AND COMBINE.

2.1.2 MODIFY AND DEVELOP.

2.1.3 RATE POTENTIAL.

2.2 Put a \$ on each idea.

2.2.1 ESTIMATE UNIT COST.

2.2.2 ESTIMATE IMPLEMENTATION COST.

2.2.3 RECORD TOTAL COST.

2.2.4 RATE BY COMPARING COSTS.

2.3 Evaluate ideas.

2.3.1 LIST ADVANTAGES.

2.3.2 LIST DISADVANTAGES.

2.3.3 RATE BASED ON RELATIVE MERITS.

2.3.4 ESTABLISH COST/VALUE RATIOS.

2.3.5 SELECT THE BEST IDEAS.

3. DISCUSSION.

In this phase we are taking the ideas listed in the creative phase and the facts gathered during the information phase and attempting to select those ideas which show the most promise of being developed into an acceptable lower cost alternative.

To do this ideas are analyzed and refined to meet all essential requirements and constraints. Creative and fact finding techniques are reapplied as necessary to develop ideas.

Ideas are then evaluated by estimating their cost and evaluating their worth. Finally, those ideas which offer the greatest potential are selected for further investigation and development.

4. DESCRIPTION OF TECHNIQUES.

4.1 Refine ideas.

4.1.0 List basic function, value and constraints in 1.0 section at top of worksheet.

4.1.1 Review all ideas on the creative worksheet with the objective of arranging into similar groupings, eliminating duplication and combining with other ideas. List in column 1.1.

4.1.2 Reapply creative techniques to refine, modify and develop these ideas to meet all the essential constraints or

requirements in the performance and environmental are. Refine ideas positively—How can each idea be made work? List changes in column 1.2.

4.1.3 Rate (rank) potential of each of these ideas as good, fair or poor in the opinion of team. Check in column 1.

4.2 Put a \$ on Each Idea.

4.2.1 Estimate the cost (unit cost based on anticipated quantities) of each idea (means of performing the function) by obtaining estimate from the team knowledge specialists. Record in column 2.1.

4.2.2 Estimate the cost of implementing the idea (tooling, engineering, evaluation, etc.). Record in column 2.2.

4.2.3 Calculate the total cost of each idea [(unit cost (2.1) times estimated quantity (info. worksheet) plus implementation cost (2.2)]. Record in column 2.3.

4.2.4 Rate each idea by comparing the total costs (2.3) each idea. Rank by number in column 2.4 (least cost = 1).

4.3 Evaluate Ideas.

4.3.1 List the advantages (other than cost) of each idea in column 3.1. Such things as appearance, reliability, maintainability, ease of assembly, quality control, size, weight, etc. should be considered.

4.3.2 List the disadvantages of each idea in column 3.2.

4.3.3 Rate each idea based on its relative merits weighting all the advantages and disadvantages. Rank number in column 3.3.

4.3.4 Establish the cost/value ratio of each idea by dividing the unit cost (2.1) by the value of the function (listed at top of worksheet). Record in column 3.4.

4.3.5 Select the best ideas (at least three) based on combined ratings in columns 1.3, 2.4 and 3.3. This should result in the selection of those ideas with the best potential.

5. DISCUSSION.

It is usually desirable to select at least three good ideas for each functional area being evaluated. These are ideas which will be followed for further development in the best alternative.

The next step of the value engineering job plan is Investigation Phase.

NOTES

Part 2. Check List—Evaluation Phase

	NO	YES
Have all ideas been reviewed?		
Has each idea been refined to see how it could be made to work?		
Has each idea been refined to meet all necessary constraints or requirements?		
Has the dollar sign been put on each idea?		
Has the implementation and tooling cost been estimated for each idea?		
Has the time to implement each idea been considered or estimated?		
Have creative thinking techniques been re-applied to refine and further develop or expand each idea?		
Have the advantages and disadvantages of each idea been listed?		
Has each idea been rated according to relative merits, cost and other advantages or disadvantages?		
Have at least three good ideas been selected as the best ideas?		
Have all functions been re-evaluated?		
Have new cost/value ratios been determined?		

It is desirable to obtain affirmative answers to as many of these questions as possible before proceeding to the next phase of the job plan.

NOTES

SECTION VII PHASE IV OF THE VALUE ENGINEERING JOB PLAN

Part 1. Description of Investigation Phase

1. THE OBJECTIVES OF THIS PHASE ARE:

- 1.1 To develop alternatives.
- 1.2 To select the best alternative.

2. THE TECHNIQUES USED IN THIS PHASE ARE:

- 2.1 **Plan an investigation program.**
 - 2.1.1 RECORD BASIC FUNCTION.
 - 2.1.2 RECORD QUANTITY REQUIREMENTS.
 - 2.1.3 RECORD THE CONSTRAINTS.
 - 2.1.4 LIST THE BEST IDEAS (DESCRIBE).
 - 2.1.5 IDENTIFY PLANS (KNOWLEDGE AND INFORMATION NEEDED).
- 2.2 **Carry out the investigation (develop alternatives).**
 - 2.2.0 USE SEARCH TECHNIQUES.
 - 2.2.0.1 Use references.
 - 2.2.0.2 Use telephone.
 - 2.2.1 CONSIDER ALTERNATE PRODUCTS, PROCESSES & MATERIALS.
 - 2.2.1.1 Search for alternatives.
 - 2.2.2 CONSIDER STANDARDS.
 - 2.2.2.1 Search for standards.
 - 2.2.3 CONSULT SUPPLIERS (VENDORS).
 - 2.2.3.1 Search for suppliers.
 - 2.2.3.2 Consult with suppliers.
 - 2.2.4 CONSULT SPECIALISTS.
 - 2.2.4.1 Search for specialists.
 - 2.2.4.2 Consult with specialists.
 - 2.2.5 MODIFY IDEAS.
 - 2.2.5.1 Use information from suppliers & specialists.
 - 2.2.5.2 Re-apply creative techniques.
- 2.3 **Compare costs.**
 - 2.3.1 DEVELOP COSTS OF ALTERNATIVES.
 - 2.3.2 COMPUTE TOTAL COSTS OF ALTERNATIVES.
 - 2.3.3 SELECT THE BEST ALTERNATIVE.

3. DISCUSSION.

In this phase, using the best ideas that were selected in the Evaluation Phase, we are planning and carrying out a program of investigation. Here we are attempting to develop the ideas into practical alternatives to the functional problem. This is done by pursuing thoroughly and intensively each of the best ideas through depth consultation with suppliers and specialists. For consultation we must provide complete information on the functional requirements so that those consulted can make detailed recommendations. From these recommendations the final best alternative is determined.

4. DESCRIPTION OF TECHNIQUES.

4.1 Plan an investigation program.

- 4.1.1 List the basic function(s) identified in the Information Phase opposite 1.1 at the top of the worksheet.
- 4.1.2 List the quantity(s) which will be required opposite 1.2.
- 4.1.3 In 1.3, list all key constraints or requirements under which the function must be performed. These constraint were previously determined in the Information Phase.
- 4.1.4 Describe three of the best ideas selected in the Evaluation Phase in the spaces 1.4 provided in section 1. If other ideas are to be investigated use additional work sheets. These descriptions should be thorough enough to completely define the ideas. If the ideas cannot be described in a few words, sketches or other attachment should be used and referenced in this space.
- 4.1.5 In this same section under each idea, describe the plan which will be carried out in this phase. This plan will identify the types of knowledge and information needed to develop the idea. Some of the things to be listed are the general classification of suppliers and specialist needed for consultation and what technical and production information is needed.

4.2 Carry out the investigation plan. (develop alternatives)

4.2.0 USE SEARCH TECHNIQUES.

Throughout this Investigation Phase search technique are employed to find the names of specialists and supplier who have the depth of knowledge needed to develop the idea. Two key techniques are used here.

4.2.0.1 Use references.

This technique requires the intensive search through a available references which list names and locations of specialists and suppliers. Some of these are: Visual Search Microfilm Files, Electronic Engineers Master, Thomas Register or McRae's Bluebook, Sweet's Catalog, Yellow Pages (telephone), Trade Journals, Business Directories, Buyers Guides, Catalogs, Standard Manuals. In addition to written or published references, information can be obtained by contacting knowledgeable people, library services, trade show exhibitors, professional societies, trade associations, etc.

4.2.0.2 Use telephone.

One of the fastest and best methods of getting information is the use of the telephone. This technique can save hours of search time. One excellent method is called "chain inquiries." This involves:

- 1. Making a phone call to a specialist or supplier.

SECTION VII PHASE IV OF THE VALUE ENGINEERING JOB PLAN

2. Describing the functional problem.
3. Requesting the names of additional sources or knowledgeable people.

By repeating this process the best source is usually found. Often, if the name of a person is not known, a call to the company or organization can be made. It is a good idea to start at the top level of the organization (such as General Manager, Sales Manager, etc.) and through them obtain the name and location of the most knowledgeable person.

By the above search techniques one will obtain the names of suppliers and specialists with whom the problem and ideas can be discussed. These people must be consulted to obtain the latest information on products, processes and materials.

4.2.1 CONSIDER ALTERNATE PRODUCTS, PROCESSES AND MATERIALS.

4.2.1.1 Search for alternatives.

In developing ideas one should give consideration to all of the possible products, processes and materials which are applicable to each idea. The search should include a thorough review of all pertinent, technical, production, manufacturing and processing publications and data. The information obtained should be recorded in the appropriate section 2.1 of the worksheet (suppliers and specialists, front and back of worksheet).

4.2.2 CONSIDER STANDARDS.

4.2.2.1 Search for standards.

Standard materials, products, tolerances, and methods are desirable because they often represent the lowest cost approach. Their use can avoid tooling, design and other costs associated with special or custom designs. The identification of usable standards will lead to the names of their suppliers which should be recorded in section 2.1. In addition to industry standards, a search should be made to identify company standards which may represent value improvements. Standard practices in regard to design, manufacturing and tolerancing should be reviewed to identify areas of potential improvement. Purchasing should be contacted to determine if any company-wide purchase agreements exist which could be used. Manufacturer's catalogs of standard parts should be reviewed. Any pertinent information gleaned from this search should be recorded in section 2.1 on the front of the investigation worksheet or in the remarks column. Enter price information in column 3.1.

4.2.3 CONSULT SUPPLIERS.

4.2.3.1 Search for suppliers.

Suppliers are business organizations which sell materials, products and services. They may be producers or sellers of basic materials, products or processes; fabricators or assemblers; or manufacturers of standard or special parts or products. They have people and facilities with special skills and knowledge which often is not recorded in textbooks. The effective use of suppliers is essential to the attainment of good value because they possess large amounts of knowledge which is not available from any other source. New developments and tomorrow's skills

are known by the engineers in most good suppliers' plants. The value analysis job is to find and use this knowledge.

Since there are many suppliers in each field and each may possess unique know-how, it is necessary to search out a list of those most likely to have that special skill and facilities which enable them to meet the functional needs with the minimum of problems and for the least cost. All the previously mentioned search techniques must be brought to bear. Contacts with buyers are essential but should not be the only source of information. Personal experience with a supplier often reveals information regarding their capability and dependability, which is useful in evaluating their potential contribution. Because of the difference in supplier skills, it is important to identify several potential sources for each idea being developed. The names of the suppliers should be listed in section 2.3 on the worksheet.

4.2.3.2 Consult with suppliers.

Consultation with suppliers cannot be done very effectively by mail because it involves more than just a request for quotation. When a list of qualified suppliers has been made, the next step is to contact them requesting a meeting to discuss the functional problem. In the meeting it is desirable that the most knowledgeable people be present. It is usually important to have their manufacturing and engineering people present as well as the salesman. While this may not be possible for the first meeting, one should at least know the position, experience and background of the person representing the firm. With engineering and manufacturing people present, first hand information can be obtained on the effect of technical and production requirements on cost. Companies are usually represented by: Sales representatives or agents, direct salesmen employed by the supplier, or other employees such as plant managers, superintendents, etc. In consulting with the suppliers there are several ground rules for effective value engineering work.

1. Don't just give the supplier a drawing and ask him to quote on the part. This is a clerical job, not value analysis.
2. Describe thoroughly the functional, technical, and production requirements indicating those that are critical and those where some flexibility may exist.
3. Advise the supplier the "rules of the game" relative to the value engineering study. Assure him that: (a) he will be rewarded if his suggestions result in reduced costs or improved value, (b) his ideas will not be passed along indiscriminately to other suppliers or used for in-house improvements, (c) he will not be exploited for his skill or knowledge without compensation, and (d) his working and cooperating with you will be to his benefit.
4. Let him know you expect honest quotations or estimates resulting in a fair profit to his company.
5. Sell the best supplier on doing business with you and assist him in putting his capabilities to work on your problems and needs.
6. Solicit his suggestions and creative skills in finding opportunities for improvements. Let him tell you what tolerance he can economically hold. Ask what there is about the design that causes high cost.

Record the name of the supplier, his address, telephone number and representative in the columns provided on the worksheet section 2.3.

4.2.4 CONSULT SPECIALISTS.

4.2.4.1 Search for specialists.

Use the same basic search techniques here as previously described. If a company is to have better value products than its competitors, then it must obtain better answers to the technical and manufacturing problems. One way to get these better answers is through consultation with the most knowledgeable specialists. The first step is to identify what technology is involved. If the function has been defined correctly using precise verbs and measurable nouns, it may also identify the area of knowledge needed for value improvement. For example, "support weight" would indicate that a strength or material specialist or structural designer could contribute. Specialists should be consulted to help solve not only the performance problem, but also the *cost problem*. Doing this will force a greater degree of technical penetration, thus revealing more opportunities for value improvements. List the names and type of specialists needed in columns 2.4 on the back of the worksheet opposite each idea.

4.2.4.2 Consult specialists.

While consultation can be done by telephone or mail, it is usually more desirable to have a face-to-face meeting with the specialist. The value analyst must then: (a) define the function and cost problem, (b) sell him on the importance and priority of his working on the problem, (c) make the specialist a part of the project, (d) direct the specialist's efforts, (e) give him credit for his contribution, (f) ask him to identify other specialists or sources of assistance. Record the information obtained from each specialist in the worksheet section 2.4. Be sure to find out what new developments exist in his field. The company which makes the broadest use of the latest knowledge can have the best value products. The effective use of specialists can remove many roadblocks.

4.2.5 MODIFY IDEAS.

Space has been provided under the idea listing (section 1) to note modifications to the idea which may result from consultation with suppliers and specialists. Inputs from these people may change a basic idea. Additional creative efforts should be carried on with each person participating to improve value. Record these modifications in section 2.5 on the worksheet so that a complete description of the idea will exist. This section can be used to reference additional sheets, sketches or drawings as needed to thoroughly define the idea.

4.3 Compare costs.

To fully evaluate each idea it must be priced out so that cost comparisons can be made.

4.3.1 DEVELOP COST OF ALTERNATIVES.

The sections 3.1 on the front and back of the worksheet provide spaces for cost information. The *unit* price from each vendor for the quantity(s) should be listed. List tooling and other non-recurring costs quoted by the

supplier. For the purpose of value analysis, cost estimate that are within 10% of accuracy may be satisfactory, at least for preliminary screening of the ideas. When it comes down to the final choice between two alternatives more precise quotations may be necessary. At least three estimates or quotes for each idea are desirable.

Columns A through J in section 3.1 on the back of the worksheet are provided for developing the total costs at a product cost level. The elements of each of these columns are identified at the top of the worksheet. The costs in each column are obtained by factoring up the prime cost(s) by the cost factors on the Information Phase worksheet. Columns A and B are supplier's prices factored up to P.C.L. and columns C through G are additional Raytheon costs also factored up to P.C.L. One should make sure that all the costs to implement and use the new methods are listed. These costs are divided into recurring (A, C & D) and non-recurring (B, E, F, & G). All recurring costs should be item costs for a given quantity.

4.3.2 COMPUTE TOTAL COSTS OF ALTERNATIVES.

The next step of the Investigation Phase is to compute the total costs of the various ideas to determine which is the lowest cost alternative. Use columns 3.2. First all the recurring and non-recurring costs must be totalled. $H = A + C + D$ and $I = B + E + F + G$. Then the total cost for each idea must be determined by multiplying the unit recurring cost (Col. H) by a given quantity and adding the non-recurring costs, (Col. I) and recording in column J ($J = HQ + I$). If it is desired to determine the quantity at which one of two ideas becomes more economical (breakeven point) it can be done by dividing the difference of the non-recurring costs by the difference of the recurring cost

$$BEP = \frac{\Delta NRC(I)}{\Delta RC(H)}$$

4.3.3 SELECT THE BEST ALTERNATIVE.

The final step of this phase is to select the best alternative. This is done by comparing the total costs in column J and by considering the other benefits of each idea. These could be Reliability, Operating, Maintenance, etc. in addition to cost savings. It may be desirable to estimate the effect on the life cycle cost of these other benefits. A space to identify these other benefits is provided in column 3.3. In this column, the best alternative should be described briefly, and the cost and savings summarized. This alternative should be carried into the Recommendation Phase.

5. SUMMARY.

The Investigation Phase is a critical one in value engineering work because, on the basis of the information gathered here, decisions may be made which determine product value, profitability, and sales. If the work is not thorough and the information is inaccurate, wrong decisions can be made. Consequently, it is as important to have the same high degree of skills applied to value work as to performance work. Before proceeding to the Recommendation Phase a careful review should be made to be certain that all factors have been considered and that the potential improvement really enhances the value of the product. When this is assured you are ready for the next step, the Recommendation Phase.

NOTES

Part 2. Check List – Investigation Phase

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Is it really the best solution?																																																																											

It is desirable to obtain affirmative answers to as many of these questions as possible before proceeding to the next phase of the job plan.

NOTES

Note: To complete idea analysis re-verse fold this quarter of page, align arrow to arrow and continue.



VALUE
ENGINEERING

INVESTIGATION PHASE WORKSHEET

SEMINAR NUMBER
PROJECT NUMBER
PAGE NUMBER OF
DATE

1.1 BASIC FUNCTION _____
verb noun
QUANTITIES: _____
CONSTRAINTS: _____

1. BEST IDEAS	2.1, 2.2, 2.3 SUPPLIERS					3.1 SUPPLIERS PRICES		REMARKS
	NAME	ADDRESS	TEL. #	REPRESENTATIVE	DELIVERY	MATL.	TOOL.	
1.4 DESCRIPTION								
1.5 PLAN								
2.5 MODIFICATIONS								
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Back of Investigation Phase Worksheet

SECTION VIII PHASE V OF THE VALUE ENGINEERING JOB PLAN

Part 1. Description of Recommendation Phase

1. THE OBJECTIVES OF THIS PHASE ARE:

- 1.1 Document the best alternative.
- 1.2 Promote implementation of the alternative.

2. THE TECHNIQUES USED IN THIS PHASE ARE:

- 2.1 Use one page recommendation form.
 - 2.1.1 IDENTIFY MAJOR EQUIPMENT AND UNIT UNDER STUDY.
 - 2.1.2 DESCRIBE PRESENT AND PROPOSED METHOD.
 - 2.1.3 RECORD PRESENT AND PROPOSED COSTS.
 - 2.1.4 RECORD IMPLEMENTATION COSTS.
 - 2.1.5 CALCULATE AND RECORD SAVINGS.
 - 2.1.6 SUMMARIZE THE RECOMMENDED ALTERNATIVE.
 - 2.1.7 LIST PROJECT TEAM MEMBERS AND LEADER.
 - 2.1.8 IDENTIFY CONTRACTUAL INFORMATION.
- 2.2 Motivate positive action.
 - 2.2.1 PRESENT RECOMMENDATION.
 - 2.2.2 FOLLOW-UP PRESENTATION.
 - 2.2.3 DETERMINE DISPOSITION.
 - 2.2.4 OFFER ASSISTANCE TO IMPLEMENT.
 - 2.2.5 DETERMINE AND OVERCOME ROADBLOCKS.
 - 2.2.6 GIVE CREDIT.

3. DISCUSSION.

The potential financial gains to the organization will not be realized if the results of the value engineering study are not implemented. The initial presentation of the recommendation must be concise, factual, accurate, and presented in such a manner as to create a desire on the part of those responsible to implement the change. The selling of the recommendation depends to a large extent on the use of good human relations. The recommendation should be presented in such a way as to avoid any personal loss or embarrassment. Proper credit should be given to those who contributed and to those responsible for implementation. The one sheet recommendation form was specifically designed to facilitate management review and motivate positive action. Additional data generated during a value study should be retained for reference.

4. DESCRIPTION OF TECHNIQUES.

4.1 Use "one page" recommendation form.

- 4.1.1 The equipment and the unit under study should be identified on the recommendation sheet by name, number and quantity.
- 4.1.2 A brief description using words or sketches of the present and proposed design or method should be entered in the space provided. (A picture is worth a thousand words.)

4.1.3 Record the unit cost at product cost level of the present and proposed designs. These costs are obtained from the Information and Investigation Phase worksheets.

4.1.4 Record and describe all the costs required to implement the recommendation (non-recurring costs). These costs are obtained from the Investigation Phase worksheet. Caution: the present and proposed unit costs should be for the same quantity and at product cost level.

4.1.5 Calculate the total net savings for the selected quantity and record on the worksheet in the space provided at the bottom right.

4.1.6 Summarize the proposal by a concise statement of the type of change involved and the benefits to be derived in the space provided on the worksheet.

4.1.7 The names of the members of the project team or those contributing to the recommendation should be listed at the bottom of the sheet with the name of the person who should be contacted for further information.

4.1.8 Since much value engineering work is done on Government equipment under program or incentive contractual clauses, a space has been provided on the worksheet for the estimated net savings for both Raytheon and the customer. If the project is on a program with a Value Engineering clause these amounts should be calculated and other related data recorded in the spaces provided on the back of this worksheet. First, the contractual information, contract number, type of contract (F.F.P., F.P.I., C.P.I.F., C.P.F.F., etc.) quantity (instant and future), schedule (dates), type of value engineering clause (program or incentive), and sharing formulas. One should refer to Government procurement regulations, circulars, and other directives for more detailed information. Second, the total net savings is recorded and the correct formula applied to determine customer and Raytheon savings for the instant contract, future acquisitions, and collateral (operation, logistics) if possible. Next, record the date by which the recommendation must be implemented if these savings are to be realized. Then, identify the fringe benefits (reliability, etc.) which would result from this recommendation listing the advantages and disadvantages of each. Note: some of this data would be used to help estimate collateral savings although such estimates may be beyond the capacity of the Value Engineer. Finally, the total savings should be recorded in the appropriate blocks in the upper right of the front of the recommendation sheet.

4.2 Motivate positive action.

4.2.1 PRESENT RECOMMENDATION.

The completed recommendation sheet should be presented to those in management with decision making responsibility. The submission of the recommendation may be accompanied by a verbal presentation or letter of transmittal. In any case, the presentation of a recommended change must be done with tact and good judgement employing all the good human relation elements discussed under General Techniques. Every attempt should be made to avoid any personal loss or embarrassment. This can be done by preconditioning management or the decision maker, establishing a proper climate that is receptive to change and making those responsible for implementing the change a part of the project. In this way people will be receptive to the recommendation and motivated to take action on it.

4.2.2 FOLLOW-UP PRESENTATION.

The presentation of a recommendation should be followed up after the recipients have had a chance to review the proposal. A personal contact is desirable, but a note or letter may be adequate. The purpose of follow-up is to determine if there are any questions, problems or additional information required.

4.2.3 DETERMINE DISPOSITION.

There should be an effort to determine the disposition of a recommendation during the follow-up. If possible, a time table and planned program to effect the change should be established.

4.2.4 OFFER ASSISTANCE TO IMPLEMENT.

Although it is not the intent that the study team or value analyst should do the work of the implementor (unless the analyst is responsible), an offer to assist in the implementation may help to motivate action. For instance, some detailed information, test data or a model may be needed.

4.2.5 DETERMINE AND OVERCOME ROADBLOCKS.

During the follow-up any obstacles to implementation should be determined and analysed to establish what

data or effort is needed to overcome these roadblocks. One can minimize problems if an effort has been made to anticipate roadblocks prior to the presentation of the recommendation. A certain amount of sales effort may be required to convince people that it is to their benefit to implement the change.

4.2.6 GIVE CREDIT.

Perhaps one of the strongest motivational methods is to give credit. To create a value consciousness, receptivity to change and spirit of cooperation, it is important to openly recognize the contribution of all persons who make the improvement possible. This includes those who have contributed information and ideas, those who have developed the idea, those who have finalized the recommendation, and *most important*, those who have to make the final decision. It is the latter who should really get credit for the change because on their shoulders will rest the responsibility for the action.

This Recommendation Phase concludes the value engineering job plan. The project has come to a successful conclusion when it has been adopted and is saving money. While implementation is important, it should not be the sole measure of the success of the project. Unforeseen circumstances, schedule, time or man-power problems may prevent the implementation of an otherwise good recommendation. Even in this case, all may not be lost because the recommendation may be applicable to other products or areas, it may be useful in the future or it may have an application in other divisions of the company. In any case, the ideas should be circulated to areas for potential use and for possible insertion into standards or preferred practices manuals.

There are some measurements, documentation and reporting that should be performed as part of the conclusion of value engineering work. This information is useful for management evaluation of return on investment. One should make sure the cost reduction or avoidance resulting from the change is submitted to the company cost reduction program. And finally, one should identify the contribution to *profit* improvement, the ultimate measure of a successful value engineering study.

Part 2. Check List – Recommendation Phase

	NO	YES
Has the best alternative been fully documented?		
Have all the constraints been considered?		
Has the one page value engineering recommendation form been filled out?		
Has the recommendation been presented to the most appropriate responsible management or decision maker?		
Has the recommended change been sold?		
Has the implementation plan been devised and carried out?		
Have the benefits to the company and the customer been documented and reported?		
Have the recommendations been presented to all areas of possible application?		
Have the benefits to the company been measured?		
Has the return on the investment been measured?		
Has the improved value design been considered for a standard or preferred practice?		
Has credit been given to all participants?		

It is desirable to obtain affirmative answers to as many of these questions as possible.

NOTES

VALUE ENGINEERING

SEMINAR NUMBER _____

PROJECT NUMBER _____

PAGE NUMBER _____ OF _____

DATE _____

RECOMMENDATION PHASE WORKSHEET

EQUIPMENT			ESTIMATED NET SAVINGS*	
DRAWING NO.			DYNA/PERT	CUSTOMER
UNIT			\$ _____ /Year	\$ _____ /Year
DRAWING NO.				
QTY. _____ /Year _____ /Contract			\$ _____ /Cont.	\$ _____ /Cont.

SUMMARY:

PRESENT:

PROPOSED:

UNIT COST (PCL) \$ _____

UNIT COST (PCL) \$ _____

IMPLEMENTATION COSTS (NON-RECURRING)

TOOLING _____ \$ _____
 ENGINEERING _____ \$ _____
 OTHER _____ \$ _____
 OTHER _____ \$ _____
 OTHER _____ \$ _____

TOTAL _____ \$ _____

SAVINGS CALCULATIONS:

PRESENT UNIT COST _____ \$ _____
 PROPOSED UNIT COST _____ \$ _____
 SAVINGS/UNIT _____ \$ _____
 QTY _____ /Year _____ /Cont.
 GROSS SAVINGS \$ _____ /Year _____ /Cont.
 IMPLEMENTATION \$ _____
 NET SAVINGS \$ _____ /Year _____ /Cont.

TEAM MEMBERS:

For Further Information, Contact _____

*See Reverse Side for Detail Data

CONTRACT DATA:

CUSTOMER: _____

CONTRACT NO. _____

TYPE OF CONTRACT: _____

QTY _____ /INSTANT _____ /FUTURE (EST.)

SCHEDULE: _____

V.E. CLAUSE: _____

V.E. SHARING: FORMULAS	NET SAVINGS		
	TOTAL	DYNA/PERT	CUSTOMER
INSTANT /			
FUTURE /			
COLLATERAL /			
TOTAL			

IMPLEMENTATION DATE: _____

FRINGE BENEFITS:

	ADVANTAGES	DISADVANTAGES
RELIABILITY		
MAINTAINABILITY		
PERFORMANCE		
OPERATION		
SCHEDULE		
LOGISTICS		
INTERCHANGEABILITY		
WEIGHT		
OTHER (SPECIFY)		

SECTION IX REFERENCE MATERIAL

Part 1. Cost and Function Analysis Techniques

In the Information Phase, section IV, Part 1, 4.2 and 4.5, a number of cost and function analysis techniques have been discussed. However, this area is so important to value analysis and value engineering work that further explanation would probably be helpful. The following techniques will be discussed.

1. COST ANALYSIS TECHNIQUES.

1.1 Cost Arrangement Analysis.

1.1.1 GENERATION BREAKDOWN.

1.1.2 HIGH \$ TO LOW \$.

1.1.3 80-20 RULE, ABC LISTING.

1.1.4 COST ELEMENTS.

1.1.4.1 *Material, labor, overhead, test.*

1.1.5 COST INCREMENTS.

1.1.5.1 *Process or method build-up.*

1.1.6 SIMILAR PARTS.

1.2 Cost Allocation Analysis.

1.2.1 COST/DIMENSION (LENGTH, AREA, VOLUME).

1.2.2 COST/WEIGHT (POUND, OUNCE, GRAM).

1.2.3 COST/TIME PERIOD (YEAR, CONTRACT).

1.2.4 COST/PROPERTY (STRENGTH, CONDUCTANCE, INSULATING).

1.2.5 COST/REQUIREMENT (TOLERANCE, SPECIFICATION).

1.3 Cost Visibility Analysis.

1.3.1 PIE CHART.

1.3.2 TREE CHART OR BLOCK DIAGRAM.

1.3.3 GRAPH OR BAR CHART.

2. FUNCTION ANALYSIS TECHNIQUES.

2.1 Value Indices Analysis.

2.1.1 COST TO VALUE RATIOS.

2.2 Functional Arrangement Analysis

2.2.1 SIMILAR FUNCTION GROUPING—FUNCTIONAL AREAS.

2.2.2 FUNCTIONAL TREE ARRANGEMENT.

Description of Techniques.

1. COST ANALYSIS TECHNIQUES.

These techniques are aimed at identifying high cost areas to assist in directing value engineering efforts to work on those elements which offer the greatest opportunity for improvement and pinpointing areas of unnecessary costs. It is these areas which offer the maximum return on investment. These techniques are essential prerequisites for functional evaluation and analysis as well as other steps of the job plan. Some of these techniques lend themselves to process, procedure and software as well as hardware analysis. They are also useful in cost targeting procedures.

While the techniques discussed here do not represent all analysis methods, they do highlight those that have been found most useful in value engineering work.

1.1 Cost Arrangement Analysis.

This technique concerns various methods of arranging costs to provide visibility from which various analyses and determinations can be made. It is very useful for cost modeling and targeting efforts.

1.1.1 GENERATION BREAKDOWN.

This involves an arrangement of all the parts of a product in a natural descending order. Starting with the final or total assembly and then descending by natural breakdown or disassembly order to the major assemblies, subassemblies and individual parts. The inverse of this order would be the way the product is assembled. The Information Phase worksheet provides space for such a breakdown in section 2.1. However, for more extensive analyses of larger products, additional sheets or computer data processing may be required. (Figure 2)

LEVEL					DESCRIPTION	DWG #
1	2	3	4	5		
X					ASSEMBLY	
	X				PART	
	X				SUBASSEMBLY	
		X			PART	
		X			PART	

Figure 2

The cost information should be recorded opposite each assembly or part in the spaces provided. (Figure 3)

QUANTITY	ITEM	UNIT	MATL	FAB	ASSY	INSP	TEST
1	5.00	5.00	1.35		2.00	0.65	1.00
2	1.50	3.00	0.50	0.50		0.25	0.25
1	2.00	2.00	0.35		1.00	0.30	0.35
3	0.50	1.50	0.05	0.15		0.10	0.20
1	0.50	0.50	0.20			0.20	0.10

Figure 3

This generation breakdown of costs provides data which is in good form for further analysis. It permits quick identification of high cost parts and assemblies. See 1.1.4 for further description.

1.1.2 HIGH \$ TO LOW \$.

From the generation breakdown a relisting of parts, subassemblies, or assemblies can be made starting with the most costly. Note: this can be done on the basis of item cost or unit cost.

Match up With Costs on Information Worksheet

[illegible]

Figure 4

1.1.3 80-20 RULE, ABC LISTING.

From this list, the items can be segregated into groups of most costly "A" items, second level "B" items and least important "C" items. An analysis of this list and associated costs may reveal that 80% of the cost of a product (unit under study) may be attributed to 20% of the parts. It is these "A" items which should then be the object of intense value analysis.

1.1.4 COST ELEMENTS.

The cost elements are constituents of the item cost such as: material, (raw or purchased parts), labor (fabrication, assembly, inspection, test), overhead, or other parts of the item cost depending on the cost accounting method which builds up to the product cost level. Some of the various factors used to obtain product cost are listed at the bottom of the Information worksheet. In an analysis of cost elements it may be desirable to break the item costs down into each element or factor to see how it builds up and to identify elements or factors which appear to be high or out of line. A separate worksheet (see Figure 4) may be desirable for further analysis of cost elements. It may be matched up with the cost section (2.2) of the Information worksheet. Note: direct labor may be actual or estimated or a standard. The variance may include labor efficiencies and the overhead may include fixed and variable elements. In any case, the analyst should know what is included in each element or constituent part and how they are obtained; and care should be exercised to be consistent in making comparisons. While a more detailed analysis of cost elements such as efficiencies and breakdown of overhead may be called for, generally it is not necessary. However, if these factors appear to be out of line, further investigation may be called for by management.

Figure 3 shows an example of the cost tabulation for the assembly of Figure 2. Note the item costs have been divided into elements. The material cost of the assembly is the sum of the material costs of the subassemblies and parts (on a unit basis). Where the part is fabricated or machined a labor figure is entered in the fabrication column. When it is an assembly labor, \$ are put in the assembly column for each item. Note, this is the labor cost to assemble the next lower level parts into that assembly, it is not a total of all lower level assembly costs. The same note applies to the inspection and test columns. If total costs in any of these areas are required, the amounts can be multiplied by the item quantities and totalled, or it is possible to put the material and labor costs in at unit cost rather than item level.

1.1.5 COST INCREMENTS.

A cost increment is the cost of a step or operation in a procedure or production process. Each direct labor cost is made up of a number of incremental costs. For instance, a fabricated or machined part is made by a number of different operations such as set-up, milling, drilling, tapping, stamping, punching, part handling, plating, etc. The cost of each of these is an increment of the total product labor cost. If it is desirable or necessary to carry the analysis to this depth then a separate process sheet should be made

out for incremental cost analysis. See Figure 5. High cost or out-of-line areas should be identified for further investigation.

1.1.6 SIMILAR PARTS.

Another analysis is done by grouping similar parts which have common shape, size, function, etc. For instance, all hardware such as bolts, nuts, washers, all chassis or cabinets, all resistors or other components, all gears, brackets, wire, etc. Sometimes the individual cost of such items is low but the combined cost of all similar items may be significant. Such analysis would open the door for a value engineering project which would develop a new concept to perform the function of these parts or might eliminate or combine parts to reduce costs. Another grouping would be by manufactured or purchased items, electrical or mechanical items, or by functions (see Function Analysis Techniques). Such groupings of costs can often reveal high and unnecessary cost areas suitable for value engineering efforts.

The cost data can be obtained from the generation breakdown either manually for medium or small projects and by data processing methods for larger projects.

1.2 Cost Allocation Analysis.

This technique concerns various methods of allocating costs to different factors which are meaningful for cost comparison purposes. When the costs have been assigned to these units significant data will have been developed which will be extremely useful for the establishing of value or cost standards and the determination of unnecessary costs. This analysis generally is helpful in pinpointing the reason for the unnecessary cost and thus guides efforts to reduce these costs.

1.2.1 COST PER DIMENSION.

For many hardware items such as machined or fabricated parts or purchased materials, cost allocated to one or more dimensions such as length, area or volume is a very useful analysis. Comparisons of cost/dimension of similar items can reveal opportunities for lower costs or better value. For example, wire costs per unit of diameter or length, insulation or molded parts per unit of volume, or certain critical dimensions on machined or fabricated sheet metal parts. On the cost increment analysis sheet, Figure 5, space has been provided for allocating costs to dimension, weight or other factors such as tolerances. In addition to process step or operation, the first column can be used to list the various parts, details or forms for cost comparisons.

1.2.2 COST PER WEIGHT.

The comparisons of costs per unit of weight (cost/pound) are among the most useful of all the analytical techniques. It is particularly important in those areas where weight is important, such as transportation. Castings, forgings, moldings followed by secondary machining or processing operations are particularly suited to this cost/weight analysis. For example, comparing cost/pound of the raw (unmachined) castings, and then comparing cost/pound at various stages (increments) of processing (machining) may indicate that one particular part is high in cost because it has difficult machining operations or it has high scrap for

COST INCREMENT ANALYSIS

Part Name _____

Part Number _____

Quantity _____/Year _____/Contract _____/Lot

Cost \$ _____ (PCL) Labor Rate \$ _____/Hour \$ _____/Min.

Step, Operation or Detail	Time		Cost				
	Hours	Min.	Operation	Cumul.	Dim.	Wt.	Req.
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							
21.							
22.							
23.							
24.							
Totals							

Figure 5

porosity or other reasons such as configuration. This technique lends itself to charting (paragraph 1.3 cost visibility analysis) and a plotting of cost/pound on graph paper for similar parts will identify those that are out of line.

1.2.3 COST PER TIME PERIOD.

The amount of cost expended over a certain time period such as per year, month, or contract is very meaningful since it indicates the rate of expenditure. This is important as a determining factor in budgeting, cost targeting, financial analysis and return on investment potential. If the dollars to be spent in a certain time period are significant, it is worthwhile to spend time and effort (dollars) to reduce them. Often the cost of a single item is not impressive but spread over the year and number of equipments it can be considerable.

1.2.4 COST PER PROPERTY.

When the end product is dependent on the property of a material for its function, this technique can reveal opportunities for value improvement. For instance, the strength of the material (tensile, yield, etc.), the conductance of wire; the insulation of plastic. By taking a convenient measure of this property and allocating the cost of the material or part per unit of this measure some worthwhile comparisons can be made which will not only reveal areas of unnecessary costs but also identify the improved approach. Plotting and functional analysis techniques can be coupled with this technique.

1.2.5 COST PER REQUIREMENT.

This technique is an analytical method related to the technique "Put a \$ on specifications and requirements" (Section IV, 4.3 Information Phase and paragraph 1.2.1 cost per dimension). Every part is made to comply with specifications or requirements which define its function and shape. These cover:

- Material
- Environment
- Life
- Dimensions
- Appearance
- Performance

and generally fall into three categories:

- Physical
- Performance
- Workmanship

in both electrical and mechanical areas. All of these requirements have tolerances which to a large degree govern the cost as indicated by the general tolerancing law which says that costs increase exponentially (at an increasing rate) as tolerances are reduced or tightened. See Figure 6.

At the same time the performance improves at a decreasing rate as shown by the performance line on Figure 6. Thus, the good design zone is where maximum desired performance is maintained for minimum cost.

By allocating cost to each dimension (requirement) and its associated tolerance, one can identify those outside or on the fringe of the good design zone. The cost increment analysis sheet, Figure 5, can be used for this analysis. It is often found that one key requirement is contributing to a large number of dollars of cost. Sometimes this dimension is not even an important or critical one.

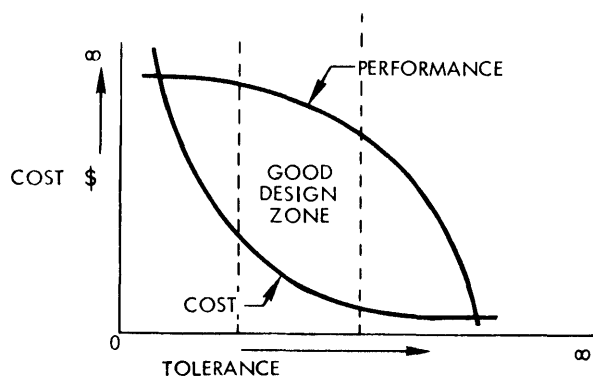


Figure 6.

1.3 Cost Visibility Analysis.

It often helps in cost analysis to be able to get a picture of the cost situation. By visualizing the relative or comparative costs in the various analysis methods described in paragraphs 1.1 and 1.2, one can readily draw conclusions regarding areas of unnecessary costs. Some of these methods of visibility analysis are summarized below.

1.3.1 PIE CHART.

If a circle or pie is representative of the total cost of a unit under study it can be divided into sections which represent the various cost elements (See paragraph 1.1.4), cost increment (1.1.5) or other cost factors. Such a chart may dramatically show that certain elements are out of line and comparison with pie charts (by overlay or section comparisons) of similar parts, units or functions will identify the amounts of unnecessary costs. See Figure 7.

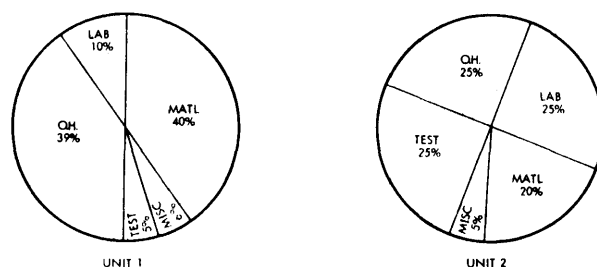


Figure 7

In unit 1 we might question the high material and overhead factors. In unit 2 the high test factor. If the area within the circle was proportioned to represent the total cost, this technique could be used to visualize relative costs of different methods of accomplishing the same functions. See Figure 8.

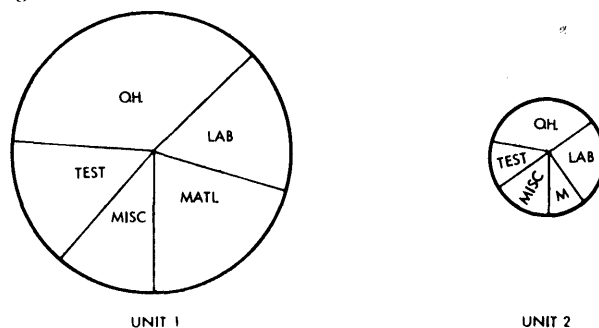


Figure 8

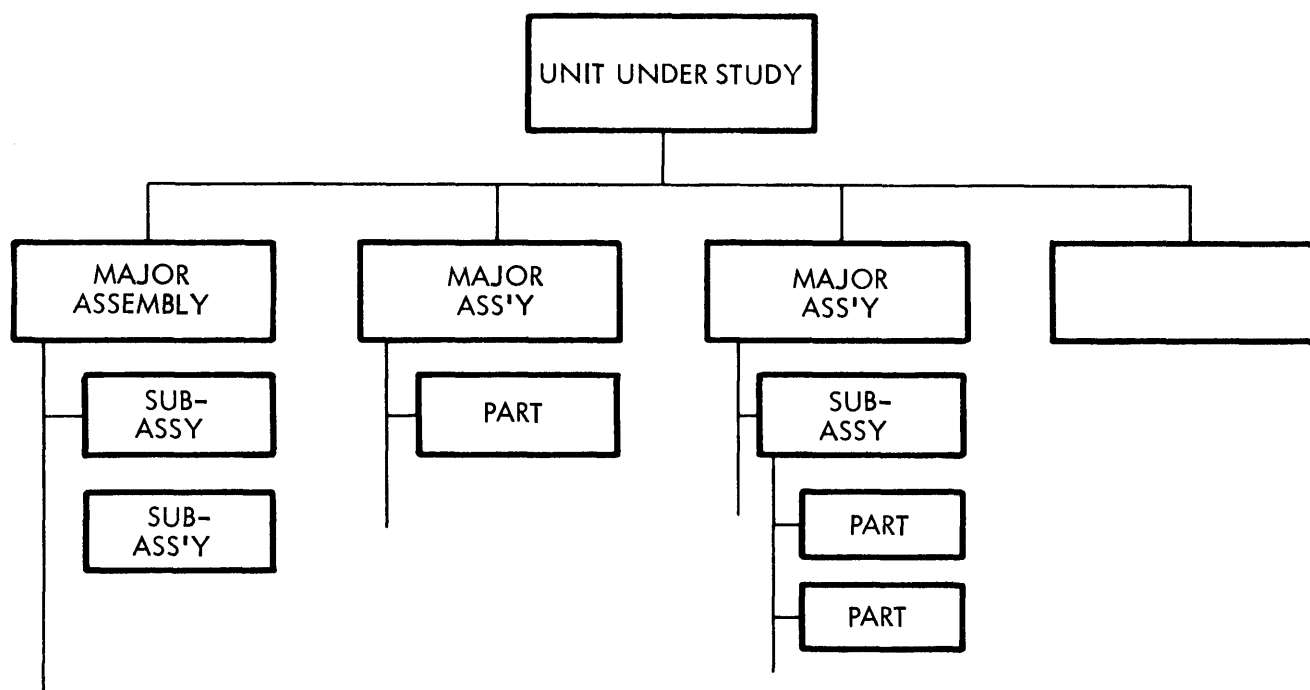


Figure 9

1.3.2 TREE CHART OR BLOCK DIAGRAM.

It is helpful, particularly for management and value analysis, to be able to visualize cost arrangements. Thus, a generation breakdown (1.1.1) could be arranged in a tree chart (See Figure 9) with costs assigned in each block.

This could be put in the form of a functional block diagram with costs allocated to each functional block. These techniques are particularly useful for cost analysis of a system, complete equipment, product or assembly. It might also be pointed out that this method of Tree or Block charting is useful in Functional Analysis (See Section 2.). In this case the functions and values would be inserted in each block in addition to costs.

This technique is also closely related to mathematical modeling, PERT cost, Gantt charts, and other analytical or control and scheduling methods. While these may be useful in helping to identify areas for the application of value analysis or for management control of programs, they are not of *prime* concern to the value analyst or the value analysis process. Consequently, they will not be discussed further in this section.

1.1.3 GRAPH OR BAR CHARTS.

Several of the above techniques (1.1 and 1.2) lend themselves to plotting on graphs by lines or bar charts. The cost allocation techniques are particularly applicable. The plotting of cost/weight or functional property for instance on rectangular, log or log-log graph paper can document in readily visible ways relative cost data which is very useful for comparison purposes and helpful for value decisions. Graphs are also useful for plotting cost/quantity data for comparison of costs of different approaches, determination of breakeven points, estimating savings and learning curve data analysis.

In cost/pound analysis, if log-log paper is used and the cost/pound plotted for several different parts which have something in common such as function, size, shape, method, etc., a 45° line drawn through the lowest cost/pound point will reveal items with higher ratios which should be analysed.

2. FUNCTION ANALYSIS TECHNIQUES.

Following functional definition and evaluation, there are some analysis techniques related to the functional approach which are useful in identifying areas of unnecessary cost. (See Section IV, 4.5.3 in the Information Phase.) Having more thoroughly described cost analysis methods (1), these functional analysis techniques may be more meaningful.

2.1 Value Indices Analysis.

2.1.1 After cost information has been determined and a value established for the function, a cost/value ratio can be established. This index is a measure of the value level (worth) of the present approach. It also is a measure of the ultimate amount of unnecessary cost or the value improvement potential. Depending on the method of evaluation of function these indices may run from 2/1 up to several hundred to one. If consistent methods are used for the evaluation of functions, it is possible to establish standards of value which indicate when an index is higher than normal. Thus, for a certain type of function, product, customer, etc. one can determine desirable cost/value ratios. A plot or chart which indicates these ratios can be analysed to identify out-of-line areas. A functional chart can be made similar to the tree chart (Section 1.3.2). See Figure 10 for an extension of Figure 9.

Each block of this chart could identify the function (verb-noun definition), the cost, value and ratio. An analysis of

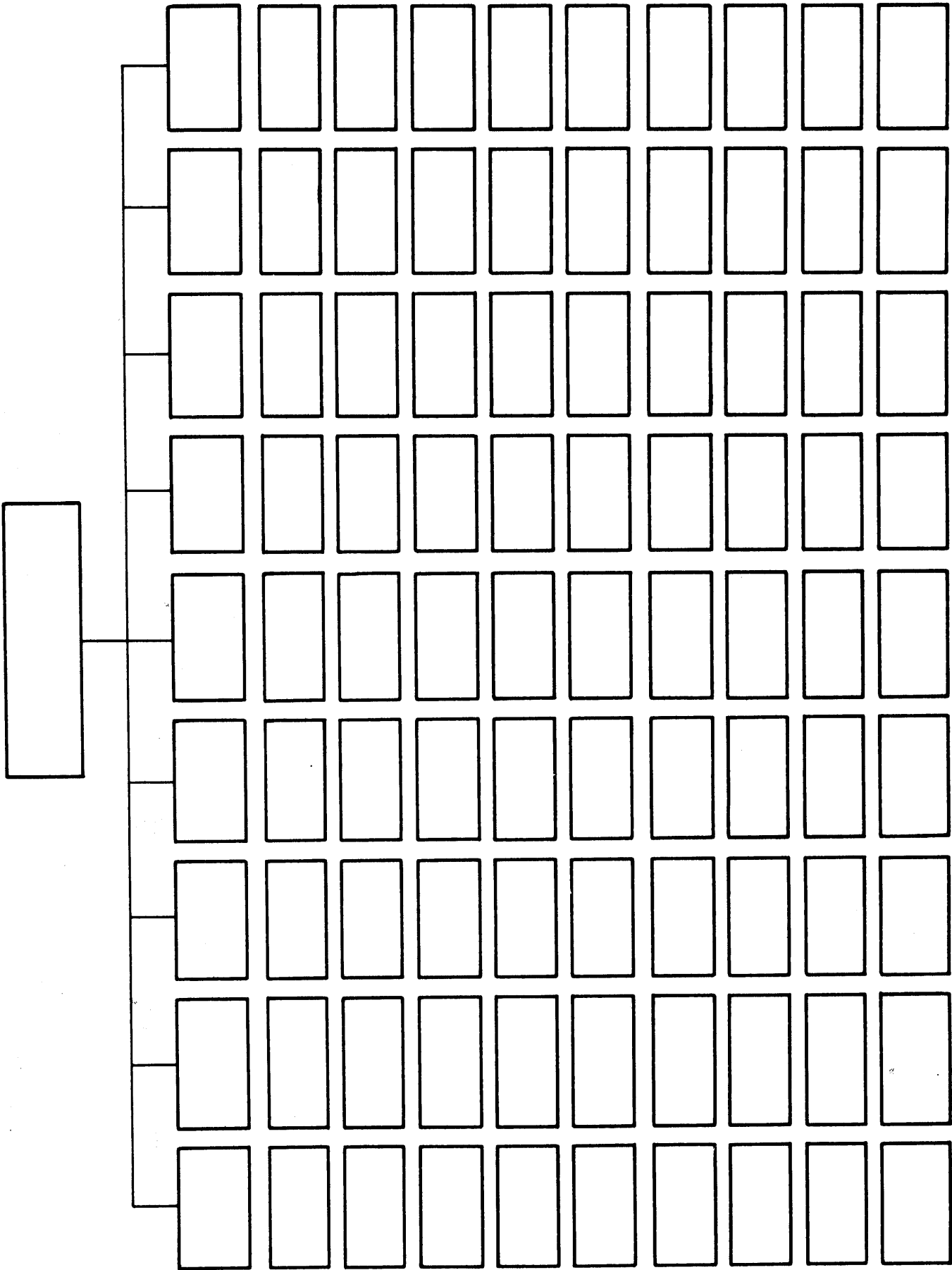


Figure 10

this chart would indicate poor and good value functional areas. The chart could be done on a generation breakdown basis and the part name put in each block, (See Figure 11) or purely on a functional basis without part names.

PART NAME	_____		
FUNCTION	_____		
BASIC	_____	2ND	_____
COST	_____	VALUE	_____ C/V _____

Figure 11

2.2 Functional Arrangement Analysis.

2.2.1 SIMILAR FUNCTION GROUPING.

In this technique the unit under study is usually an assembly or product, system or equipment. It is divided into various functional areas such as mechanical, electrical, appearance, convenience, protection, etc. These can be subdivided into subfunctional areas. This can be done by listing or by use of pie or tree charts. Costs are allocated to these functional areas. An analysis may reveal that the major cost elements are associated with secondary functions. This technique will also identify redundancy (duplication) and unnecessary costs.

2.2.2 FUNCTIONAL TREE ARRANGEMENT.

This technique has been discussed in several previous

sections. However, it is one of the most useful techniques and can be used to visually present cost and functional data and relationships which are most helpful in analysis. For instance, the functions can be grouped and classified into basic and secondary. The secondary functions can be classified as essential and nonessential. By use of solid lines connecting the blocks, it is possible to identify those parts or functions which are basic to the next higher assembly, and nonessential functional areas can be highlighted for further investigation. Sometimes it is desirable to put the input and output information on these functional charts. The charts can be used in conjunction with the functional listing, definition and evaluation columns on the Information Phase worksheet.

Summary.

These cost and function analysis techniques are an essential part of value analysis/engineering work. They are first used in the Information Phase but can and should be used throughout the job plan, as necessary or desirable, to compare, analyse and present the cost and functional picture. Not all these tools (techniques) need to be used for each job. With experience the analyst or engineer will determine which method is best suited to his decision making process and will best meet the needs of the problem,—finding a better method, procedure, design or product.

If used well they will help you to reach *better* decisions —*faster*.

SECTION X INDEX

Index and Glossary of Terms

Term	Section	Part	Paragraph
Cost— A monetary measure of the amount of material and labor required to produce a product or service.	IV	1	4.2
Cost Analysis— Techniques of analysing costs for the purpose of identifying high and unnecessary cost areas.	IX	1	1
Cost Arrangement Analysis	IX	1	1.1
Cost Allocation Analysis	IX	1	1.2
Cost Visibility Analysis	IX	1	1.3
Cost Comparison—	VII	1	4.3
Cost Determination—	IV	1	4.2
Cost Elements— Constituent parts of the cost such as material, labor, overhead.	IX	1	1.1.4
Cost Increments— Cost of each step or operation in a process or procedure.	IX	1	1.1.5
Cost, Overall, Total, Life Cycle Notes: The sum of all costs to acquire, operate, and maintain the product or service.	IV	1	4.5.3
Costs, Unnecessary— Those costs not required for the reliable performance of the necessary function.	II	3	—
Constraints— Notes: Conditions or requirements under which the function is performed.	IV	1	4.4
Function— The natural or characteristic action performed by a product or service to make it work or sell.	IV	1	4.4 & Notes
Function Analysis— Techniques of analysing functions to help identify unnecessary costs.	IV IX	1 1	4.5.3 2.
Function, Basic— An action which is the primary purpose for the existence of the product or service.	IV	1	4.4
Function Definition— A technique of identifying and clarifying the function performed by a product or service, or required by the user.	IV	1	4.4
Function Evaluation— A technique to establish an appropriate cost or worth of a function.	IV	1	4.5
Function, Secondary— An action which does not contribute directly to the basic function of a product or service.	IV	1	4.4.3 & Notes

Index and Glossary of Terms (Continued)

Term	Section	Part	Paragraph
Value— The measure of the relationship between function and cost.	IV	1	4.5.1
Value, Maximum— The lowest overall cost to achieve the necessary function reliably.			
Value, Good— The most optimum cost at which the desired function can be achieved at any specific time and place.			
Value Index (Cost/Value Ratio)— The ratio of the cost to achieve the function to the maximum value of the function.	IV IX	1 1	4.5.3 2.1
Value Analysis/Engineering— The systematic application of recognized techniques which identify the function of a product or service, establish a value for that function and provide the necessary function reliably at the lowest overall cost.	—	—	—
Value Engineering Job Plan— The sequential steps or phases of carrying out a value engineering study.	II	1	2.1
Value Engineering Objectives— The aims of each phase of the Job Plan.	II	1	2.2
Value Engineering Projects—(Selection of)— The item or problem under value engineering study.	III	1	—
Value Engineering Study— The application of the value engineering job plan and techniques.	III	1	—
Value Engineering Teamwork (Team Approach)— The integrated, coordinated effort of people with various talents.	III	2	—
Value Engineering Techniques— The procedures or methods used in value engineering work.	II	1	1.4 & 2.5
Value Engineering Chart—	II	2	—
Value Engineering—General Techniques— The techniques used throughout all value engineering work.	II II	1 3	2.5 —
Value Engineering Specific Techniques— The techniques used in each phase of the Job Plan.	II	1	2.4

NOTES

NOTES