ESD-TR-68-142

VALUE ENGINEERING ON THE BUIC III CONTRACT

John E. Crnkovich

30 November 1967

416M/P/418L AIR WEAPONS SURVEILLANCE AND CONTROL SPO
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

(Prepared under Contract No. F19628-67-C0026 by System Development Corporation, 2500 Colorado Avenue, Santa Monica, California 90406.)

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FOREWORD

This report was prepared by the Value Engineering Staff at System Development Corporation (SDC), 2500 Colorado Avenue, Santa Monica, California, under contract with the 416M/P/418L Air Weapons Surveillance and Control SPO, Electronic Systems Division, L. G. Hanscom Field, Bedford, Mass. It describes the Value Engineering effort on the BUIC III contract for the period 1 July 1967 to 30 November 1967.

The author is indebted to M.E. McCormick, who ably assisted in the implementation of the VE Plan, and in addition, provided a technical review of this report.

This Technical Report has been reviewed and is approved.

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ABSTRACT

This document contains a report on the application of Value Engineering/ Value Analysis techniques to the BUIC III contract, which is basically a software (computer programming) contract. It describes the procedures used, the problems encountered, and recommendations for VE on future software contracts.

CONTENTS

SECTION I

I. INTRODUCTION

Within the last twenty years computer programming has mushroomed into a multi-million dollar industry. As with most hastily developed industries, this phenomenal growth has been accompanied by a great amount of technical enthusiasm and a corresponding lack of control and standardization. As experience is gained in program production, it is apparent that many of the business management techniques, with appropriate modifications, are applicable to program production. One of these management techniques, Value Engineering, has been a part of government hardware contracts for some time.

The BUIC III contract, dated 1 October 1966, received by SDC was a Cost Plus Fixed Fee (CPFF) contract and was in excess of $1,000,000. Pursuant to Armed Services Procurement Regulation (ASPR) 1-17, a Value Engineering Program Requirement clause was levied upon the Contractor. Prior to receipt of this contract, the Contractor: (1) had not previously been involved with any Value Engineering (VE) requirement, and (2) the application of Value Engineering techniques to the Contractor's prime area of interest--computer program development and production--was open to question. With these two potential problem areas in mind, the Contractor proceeded to generate a Value Engineering Plan which described his outline for an in-house training and education program, for selection of high-cost contract areas for analysis, and for Value Analysis procedures.

To our knowledge the BUIC III contract was the first computer program contract in which the ASPR Value Engineering program clause was applied. This interim Technical Report contains the contractor's VE plan as applied to the contract, the initial results of the implementation of the VE plan, the problems encountered, and recommendations for future actions.

II. DEFINITION OF TERMS

A. Value Engineering

"ASPR 1-17, Revision 23, dated 1 June 1967, defines Value Engineering as "a systematic and creative effort, not required by any other provision of the contract, directed toward analyzing each contract item or task to ensure that its essential function is provided at the lowest overall cost."

B. Value Analysis

Value Analysis is the assessment of the value of a product, process, or procedure, including close scrutiny and definition of its functions and comparative costs of performing those functions in other reasonable ways.

C. Value Assurance

Value Assurance results from the application of Value Engineering techniques during the initial creative phases of a functional process. Value Assurance efforts are intended to assure a high value product or process before, rather than after, production begins. It parallels the purpose and meaning of other similar phases such as reliability assurance and quality assurance.

D. Software

As used in this report, software encompasses those procedures, documents, and activities required for the development, design, production, testing, and updating of a computer program system, including the training procedures required to operate the system.

SECTION II

III. IMPLEMENTATION OF THE VALUE ENGINEERING PLAN

The proposed Value Engineering Plan received approval in May 1967. Contract coverage, however, did not begin until 1 July 1967. The plan outlined the main VE functions to be performed.

A. Training

Since the contractor's prior exposure to Value Engineering was minimal, a basic 10-hour seminar was provided for some 60 selected supervisory and technical personnel. References 2, 3, 4, and 7, and 14 in Appendix B provided the base for the seminar. The 10-hour seminar consisted of five 2-hour sessions. The outline for the sessions is contained in Appendix A.

B. Organization

An attempt was made to employ Value Engineers who had a background in software production. None were available and two VE personnel were chosen from in-house. Each had a minimum of ten years experience in program or training materials production, and both had previous experience in cost-effectiveness and quality assurance work. In the belief that morale holds up better and that there is a resulting better chance of getting Value Engineering changes accepted in-house if the individuals actually performing the job participate in the Value Analysis, SDC chose the staff approach method of organization. After investigation of areas where savings were deemed possible, study teams were organized, with representation from system design, program design, programming, and Value Engineering areas.

Depending upon the functional area being investigated, the study team was headed by the most cognizant member of the team, with the Value Engineering member either heading the study or simply participating in it.

C. Value Analysis

As mentioned previously, funding for the Value Engineering effort did not begin until 1 July 1967. This late start limited the effectiveness of the proposed Value Engineering Plan. To achieve optimum results, Value Engineering personnel must participate in the generation of the contract proposal, and a detailed Value Engineering Plan, complete with goals and costings, should be a part of the proposal. It is most important that immediately after contract negotiations, the Statement of Work be thoroughly analyzed by Value Engineering personnel for high-cost areas and for assignment of VE teams for functional analysis. Predicted or potential savings should not be made until this initial analysis.

Since it was not possible to follow this schedule for BUIC III, the VE effort was at a distinct disadvantage in attempting to analyze the technical functional areas, because program requirements and design were set in concrete and any changes to them were apt to place the contract schedule in jeopardy. In at least one area of analysis, a potential savings was deemed possible; but upon further investigation, it was discovered that the items in question were already produced using the old method, and there was to be no further production under the terms of the contract!

D. <u>Selection of Value Engineering Tasks</u>

For VE purposes, the computer program production process can be divided into three areas for analysis:

- The means of inputting data to a computer.
- The processing of data by the computer (the computer program).
- The outputting of the description and use of the program system (documents).

Realizing that pure programming system functions are too far downstream for Value Analysis, the Value Engineering effort concentrated on the analysis of computer inputs and outputs. Several VE studies were undertaken with the following results.

1. <u>Use of optical scanner as an input device</u>. The present method of using punched cards to initially input data to a computer was analyzed. Optical scanning of specially typewritten materials was studied for potential cost savings. The study indicated that available scanners do not lend themselves to present SDC input requirements. As further industry advances are made, scanners should be examined again for application to BUIC III inputs.

2. <u>Standardization of input manuscripts</u>. Presently a variety of colorcoded and columnated manuscripts are used to input data. A study is currently underway to determine if a standard coding manuscript of 80 columns can be used. Specially made plastic overlays will be used to specify columnar headings. The present average cost of manuscripts is $ .04 each. Anticipated cost of a standard manuscript is $ .01.

3. <u>Use of a program to produce documents</u>. An automatic means of producing and updating program documentation (Text 90) was analyzed. A VECP for using Text 90 for each of the three BUIC III CEIs was submitted to the SPO for consideration. It is significant to note that had these three VECPs been proposed and approved in the early stages of the contract, savings on the order of $70-80,000 would have resulted instead of the $9,000 as estimated in the VECPs. The importance of performing the Value Analysis as early in the contract as possible cannot be overemphasized. These VECPs were disapproved by the SPO because the contractor did not provide for turnover and updating of the Text 90 program as part of the VECP.

4. Elimination of unnecessary training tapes. Elimination of cross-tell simulation tapes for training purposes was examined. Although it was found that the tapes could be replaced by cards at a savings, there was insufficient remaining production to amortize implementation costs.

5. Use of microfiche in lieu of hard copy documents. The use of microfiche copy is currently being examined. Initial page costs of $ .40 for hard copy vs $ .05 for fiche and reproduction costs of $ .0125 for hard copy vs $.003 for fiche make the potential savings realizable. It is anticipated that significant savings, both in the BUIC III and future contracts, will occur by the substitution of microfiche for a hard copy document. All users of the microfiche will be provided a reader, and all personnel will have access to a reader-printer, if a hard copy reproduction is necessary.

Because of time constraints, it was not possible for VE personnel to analyze the BUIC III program system prior to its production. Program system functions can and should be analyzed by trained VE personnel. The functions of a computer-based air defense command/control system generally include the following:

1. Executive control.
2. Environment definition.
3. Identification.
4. Sensor data processing.
5. Console switch interpretation.
6. Manual data insertion.
7. Digital and situation displays.
8. Weapons control and assignment.
9. Weapons guidance.
10. Data link input and output.
11. Communication message make up.
12. Height information processing.
13. Telling information to adjacent and higher commands.
14. Recording of vital data.
15. Simulation for exercising purposes.
16. Restart capability.

The Value Engineer should examine each one of those functions, asking the following questions.

1. Are common program subroutines written only once and accessible by all computer program components (CPCs)?
2. Is the data base made up compactly and for ease of later updating?
3. Do functions, subfunctions, or subroutines presently exist in another program system, which can be used with little or no modification?
4. Are CPCs broken into the best possible elements? Can some be combined? Are they operated in the least time-consuming sequence?

5. Are table lookups or direct conversion routines the best means of performing a function?
6. Can any of the CPCs be coded using a higher-order language? Is it worthwhile to do this for certain CPCs and/or refine them manually?
7. Are the number of interfaces between CPCs and CEIs at a minimum?
8. Does the Contract Data Requirements List contain unnecessary data items? Can the quantities of data items be reduced?
9. Are all test procedures necessary? Can tests for standard program routines, that have previously undergone testing, be deleted or reduced in scope?
10. In a multiple-site system, are installation teams required at each facility, or can a test team be located at a central source to provide service to all sites?
11. If training materials (simulation tapes, exercise maps, lists, scripts, cards, etc.) are a CDRL requirement, can they be reduced in number or can acceptable substitutes be provided?

SECTION III

IV. PROBLEMS

In addition to the usual roadblocks encountered in attempting to apply VE to software, others, perhaps unique to the software industry, came up during the implementation of the VE Plan. Some of these can be overcome through training and by writing enough programs for all the available computers, so that programming primarily becomes a task of putting together already programmed functions. As the roadblocks were uncovered by the VE staff, discussions were held with the technical personnel to overcome the blockages. A short description of each roadblock, with the VE response, follows.

A. Programming as a Unique Effort

Because of the unique requirements (mission, equipment, personnel of the BUIC III command/control system), programming is to a large degree a one of a kind effort. Except for the general logic involved, programs cannot be simply taken off the shelf and put together to meet the software requirements.

VE Response

Any task function, even a unique one, can be laid out in a VE job plan. Whenever the details and related costs of a task function are laid open for analysis, it is a rare occasion when the analysis does not lead to lesser costs. In instances where costs are not reduced, close scrutiny of each program component can result in increased performance and/or reduced operating size.

B. Lack of Repetitive Production Costs

In any hardware contract where multiple assemblies are specified, a relatively small VE savings per assembly can result in substantial overall savings. For example, in a contract calling for 5,000 identical assemblies, a savings of only $10 per assembly results in a total of $50,000 saved. The $10 savings per unit can probably be realized without any disruption to the work force, since the savings in materials requires a change in the type or quantities purchased and, in manpower, a reduction in production time which can be used to produce the same or other items for another customer. In short, it is not necessary to have large individual VE changes in hardware projects to produce cost reductions. This does not hold, however, in the production of computer programs. In command/control systems such as BUIC III, an overwhelming proportion of contract dollars is used in the production of the initial computer program. Even though 40 to 50 copies of the master tape containing the computer program may be required, the cost of reproducing these tapes is minute compared to the original production costs.

VE Response

Because of this unusual proportion of production costs, VE analyses to be worthwhile must result in significant savings per single application. SDC estimated this figure to be a minimum of $5,000; this estimate was used to take care of any error and delay in the implementation of a change. Again, a VE job plan is effective in bringing to light potential cost savings. While it is true that some of the savings may be small because of the one-of-a-kind production nature of software, they can result in a substantial savings if lumped together and used to reduce overall contract costs.

C. Ratio of Production Costs

The relation between the dollars spent on contract wages and salaries and those spent on materials also presents an unusual proportion. In SDC Proposal 355(D) on the BUIC III contract, an overwhelming proportion (93.6%) of the cost was for direct salaries, burden (supervisory staff, fringe benefits, administrative overhead), travel, and field allowances. Any large VE savings must come out of this wage and salary pot. Since the assets and productive talents of any software organization are represented by a reservoir of professional skills, any really large and significant VE change will probably result in a disruption of these people either by reorganization or termination. There is not usually a "backlog of orders" to fill the void created by such an event. Contracts are let with specific start and end dates and must be staffed as called for in the contract. Unless a contractor is engaged in many contracts at the same time, it is impossible to smooth out the production peaks and valleys.

VE Response

While this problem creates a challenge for any management, it can be overcome by a change in management organization, planning, and costing techniques. For future contracts, SDC has organized software capability pools such as specification writing, programming, and testing. With this kind of organization several contract tasks may be processed in parallel. By further dividing functional tasks, more than one contract can be serviced by the same individual "simultaneously." For example, rather than providing a single cost charge number for a large task function such as the production of the Air Defense Program CEI, this large task can be broken down into smaller task functions such as Part I Specification production, Part II Specification production, etc. Each of these subtasks can further be broken down into subsubtasks such as data gathering, data coordination, draft specification publication, draft specification review, and final specification publication. Costs and schedules are assigned and evaluated for each subsubtask. A master schedule of tasks is monitored, with personnel assigned on a task, rather than a contract basis.

D. Lack of Detailed Costs

Although the term "production" is used in the computer program development process, the production process is more in the nature of a service, for each program system represents a specific solution to a specific requirement. If in large contracts it is reasonable to assume that some functional areas are overcosted and overspecified, is it not reasonable to assume that some functional areas have been undercosted and underspecified? While the contractor gets to share in the savings of an approved VECP, who gets to share in the losses that he may sustain because of underestimating costs?

VE Response

Breaking down task functions into subtasks and subsubtasks will permit a more accurate assessment of costs, in both proposal and contract performance. If programs or program functions can be eliminated without degrading the Air Defense mission, they should be the subject of a VE study team.

E. Lack of Contract Details

By its very nature a command/control computer program contract cannot be specific; the numbers and kinds of programs; the numbers and kinds of data tables, etc., are the tasks to be provided under the terms of the contract. Although the BUIC III Statement of Work did specify the gross program systems to be provided--the Air Defense Computer Program, the System Exercise Computer Program, and the Utility Computer Program--it did not specify further details concerning the construction of these program systems. To qualify as a VECP, a change must save money and require a change to the contract. By definition then, changes to programming techniques, methods, tables, registers, etc., would not qualify as VECPs.

VE Response

Although Value Engineering Change Proposals may be limited because of the definition of a Value Engineering Change, the Contractor can reduce the total contract costs through Value Analysis techniques.

SECTION IV

V. SUMMARY AND RECOMMENDATIONS

In spite of the unique roadblocks described previously, software is amenable to the techniques of Value Engineering. Because of the non-repetitiveness and the one-of-a-kind nature of software, VECPs, as currently defined, must necessarily result in large individual savings. High dollar VECPs are therefore unlikely, particularly during the acquisition phase of the software system; however, application of VE techniques early in the system life cycle can result in intangible savings through improved performance and efficiency, or even of assuring contract performance. These savings, though intangible, can well be worth any measurable dollar savings. For example, a frequent cause of complaint by a program system user is that the system does not perform according to specifications. Program systems are so interleaved and interwoven that the later this is discovered, the more difficult and more costly it is to remedy. By having VE personnel participate in the program design phase, the probability of this occurring is lessened.

The greatest VE savings can occur in the preproposal period. A well-trained, conscientious VE staff can best perform at that time, because technical details are not frozen and line personnel are not as adamant about change as they are after the contract is received. It is paradoxical that the opportunity for the greatest savings exists BEFORE the contractor qualifies for sharing under the terms of any VE contract clause. On large competitive procurements, the definition phase of the system procurement provides the necessary time to perform the Value Analysis. On sole source Cost Plus Fixed Fee (CPFF) procurements, this activity is best done during the preproposal activities or immediately after the contract is received.

The necessity of valid cost data cannot be overemphasized. While cost data is available for repetitive operations such as the inputting of data to a computer or the outputting of data as a document, they are not available for system design, or program design, or program coding, except in the form of gross historical data. Cost data for these latter subfunctions need to be carefully developed. If computer program VECPs are to be produced during the system acquisition phase, some means must be developed to assign a dollar value to the savings accrued from a reduction in computer register space or reduction in program operating time.

The following additional points on VE are recommended for further software procurement:

A. <u>Initial Use of VE</u>

For software companies who have had no Value Engineering program in existence, a minimum of three months should be allowed to set up a program. Reasonable costs for this are allowable under paragraph 1-1705.3 of ASPR.

B. A Program Index as a VE Tool

As with any task, tools make the task easier. Within the past fifteen years, the Air Force has spent millions of dollars on software. In many cases it has paid for the same programming function more than once, because both the Air Force and the contractor were unaware that the function had previously been programmed. The author was unable to determine if an index or catalog exists of all Air Force-purchased computer programs, computer program systems, and computer program subroutines. Such an index of all program functions, detailing the function, the language used, the computer used, etc., would be of immense value to a software Value Engineer. Programming of mathematical functions, for example, could easily be off-the-shelf programming.

C. Early Application of VE Techniques

The dollar advantage of applying VE techniques as early as possible in the contract cannot be overstated. With contracts lacking a definition phase, Value Analysis is best accomplished in the preproposal, and Statement of Work preparations. While this is advantageous in hardware procurement, it is doubly necessary in software procurement. With few exceptions, true software VE changes are not practical after the SOW has been published. A true software change is one requiring a change to the computer program requirements and a concomitant change to the contract or Part I or Part II Specifications.

D. Cost Tree

As early as possible a functional cost tree should be prepared as shown in Figure 1. A similar chart could be devised for any software contract. In the example shown, the three BUIC CEIs have been divided into several subfunctions. The chart is not meant to be complete and is only shown as a guide for laying out functional costs. Using the predetermined cost of each CEI, Value Engineering personnel should perform a detailed cost analysis for each major function. Those functions which appear to have potential cost savings should be assigned a target cost reduction figure. This figure should be lower than the contract-estimated cost and should be established as the least cost required to perform the function. Monitoring points must be set up so that predicted cost expenditures can be compared with actuals and decisions made accordingly. Some functions, such as installation, do not lend themselves to a new target cost.

E. Participation of VE Personnel at Test and Design Reviews

It is mandatory that VE personnel participate in the various reviews and tests that occur during the acquisition phase of a system. This includes the System Design Review (SDR), Preliminary Design Review (PDR), Critical Design Review (CDR), First Article Configuration Inspection (FACI), Preliminary Qualification Test (PQT), and Final Qualification Test (FQT). Their influence can be felt most during the System Design Review and declines as the program proceeds through its acquisition cycle.

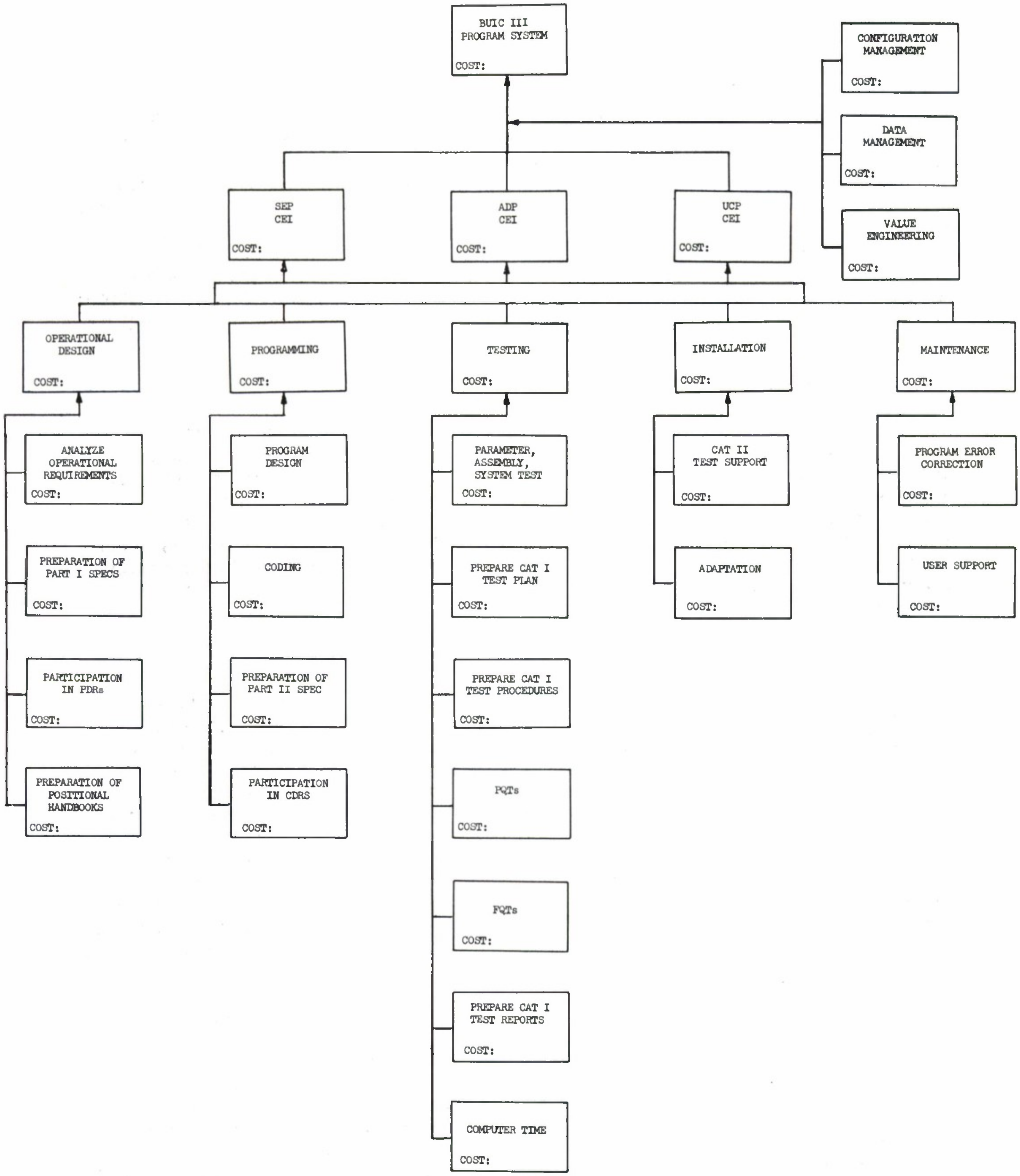
BUIC III PROGRAM SYSTEM COST:
CONFIGURATION MANAGEMENT COST:
DATA MANAGEMENT COST:
VALUE ENGINEERING COST:
SEP CEI COST:
ADP CEI COST:
UCP CEI COST:
OPERATIONAL DESIGN COST:
PROGRAMMING COST:
TESTING COST:
INSTALLATION COST:
MAINTENANCE COST:
ANALYZE OPERATIONAL REQUIREMENTS COST:
PREPARATION OF PART I SPECS COST:
PARTICIPATION IN PDRs COST:
PREPARATION OF POSITIONAL HANDBOOKS COST:
PROGRAM DESIGN COST:
CODING COST:
PREPARATION OF PART II SPEC COST:
PARTICIPATION IN CDRS COST:
PARAMETER, ASSEMBLY, SYSTEM TEST COST:
PREPARE CAT I TEST PLAN COST:
PREPARE CAT I TEST PROCEDURES COST:
PQTs COST:
FQTs COST:
PREPARE CAT I TEST REPORTS COST:
COMPUTER TIME COST:
CAT II TEST SUPPORT COST:
ADAPTATION COST:
PROGRAM ERROR CORRECTION COST:
USER SUPPORT COST:

FIGURE 1

APPENDIX A

First 2-Hour Session

1. Definition and history of value engineering and a list of applicable references.
2. Types of value engineering contract clauses, and responsibilities under each clause.
3. Percentage of total contract cost to be spent on value engineering.
4. Kinds of returns expected from a value engineering program.
5. Roadblocks encountered in moutning a value engineering effort.

Second 2-Hour Session

1. Organization and responsibilities of a value engineering office.
2. Approach to value analyses.
3. Application of value engineering to computer program.
4. Necessity of obtaining accurate costs for value engineering.
5. Selection of computer program functions for value analysis.

Third 2-Hour Session

1. How to cost a VECP for computer programs.

Fourth 2-Hour Session

1. How to initiate and process a VECP.
2. The importance of schedules in a VECP.

Fifth 2-Hour Session

1. Possible pitfalls and problems in value engineering.
2. Reporting on value engineering.
3. Assessing the effectivity of a value engineering program.

APPENDIX B

VALUE ENGINEERING REFERENCES

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13. ABSTRACT

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Value Engineering						
Computer Programming						
BUIC III						
Software						