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THESIS

THE USE OF LIFE CYCLE COSTING FOR
THE ACQUISITION OF NON-MAJOR SYSTEMS AT
THE NAVAL REGIONAL CONTRACTING CENTER,
DETACHMENT, LONG BEACH, CA

by

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The use of Life Cycle Costing (LCC) has many potential benefits for the Government. These benefits range from reduced total ownership costs to increased reliability to improved maintainability. However, prior to applying the LCC technique, an analysis should be conducted to determine its usefulness. Consequently, the purpose of this thesis is to assess the applicability of the LCC concept to the purchase of non-major systems at the Naval Regional Contracting Center (NRCC), Detachment, Long Beach. The primary method of achieving this objective was through modifying the Graham LCC Decision Model for Spare Parts so that the Model could evaluate the usefulness of LCC for the purchase of a particular non-major system. Through the use of the Modified Graham LCC Decision Model, telephone and personal interviews, and a thorough literature review, the researcher found the usefulness of Life Cycle Costing for the acquisition of non-major systems at the NRCC, Detachment to be very limited.

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The Use of Life Cycle Costing for the Acquisition of Non-Major Systems at the Naval Regional Contracting Center, Detachment, Long Beach, CA

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ABSTRACT

The use of Life Cycle Costing (LCC) has many potential benefits for the Government. These benefits range from reduced total ownership costs to increased reliability to improved maintainability. However, prior to applying the LCC technique, an analysis should be conducted to determine its usefulness. Consequently, the purpose of this thesis is to assess the applicability of the LCC concept to the purchase of non-major systems at the Naval Regional Contracting Center (NRCC), Detachment, Long Beach. The primary method of achieving this objective was through modifying the Graham LCC Decision Model for Spare Parts so that the Model could evaluate the usefulness of LCC for the purchase of a particular non-major system. Through the use of the Modified Graham LCC Decision Model, telephone and personal interviews, and a thorough literature review, the researcher found the usefulness of Life Cycle Costing for the acquisition of non-major systems at the NRCC, Detachment to be very limited.

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I. INTRODUCTION

A. AREA OF RESEARCH

Life Cycle Costing (LCC) is a means of determining the total cost of ownership over the entire service life of an asset. [Ref. 14:p. 9] Quite often ownership costs, such as support or maintenance, far exceed the initial acquisition cost of an item. Consequently, using the lowest bid as a means of selecting a contractor is meaningless if the lowest cost is defined only as the initial purchase cost. During an era of diminishing defense budgets and increasing scrutiny of the procurement system, LCC may be a means for contracting officers to select contractors that provide quality products with the lowest total ownership costs. Thus, the focus of this thesis is to determine whether the use of Life Cycle Costing is feasible for the acquisition of non-major systems at the Naval Regional Contracting Center (NRCC), Detachment, Long Beach, CA.

B. OBJECTIVES OF THE RESEARCH

The primary objective of this research effort is to ascertain if the use of Life Cycle Costing at the NRCC, Detachment, Long Beach is beneficial when procuring non-major systems. Furthermore, this research effort has three secondary objectives. One is to define the LCC concept; this information will provide the reader with the theoretical framework necessary for the practical application of LCC at the NRCC, Detachment. A second supplementary objective is to modify the Graham LCC

Decision Model for Spare Parts so that it is suitable for selecting non-major systems which are viable LCC candidates. The final secondary objective is to use the Modified Graham LCC Decision Model for Non-Major Systems to determine which items purchased by the NRCC, Detachment from 1 January 1990 to 16 January 1992 are valid LCC candidates.

C. RESEARCH QUESTIONS

The principal research question for this study is: Should the Naval Regional Contracting Center, Detachment, Long Beach apply the Life Cycle Costing concept to the acquisition of non-major systems in support of its customers?

The five subsidiary research questions are:

1. What is Life Cycle Costing?
2. Under what conditions should Life Cycle Costing be used?
3. What is the Graham Life Cycle Costing Decision Model for Spare Parts?
4. What modifications are required to adapt the Graham Life Cycle Costing Decision Model for Spare Parts to purchases of non-major systems by the NRCC, Detachment?
5. Using the criteria specified in the Modified Graham Life Cycle Costing Decision Model, what types of requirements procured by the NRCC, Detachment between 1 January 1990 and 16 January 1992 are valid candidates for Life Cycle Costing?

D. RESEARCH METHODOLOGY

The research data were collected for this study using three techniques. The first method of collecting data consisted of a thorough review of the existing literature on Life Cycle Costing. The categories of literature reviewed included: Defense

Logistics Studies Information Exchange (DLSIE) studies, Defense Technical Information Center (DTIC) studies, Naval Postgraduate School Masters of Science theses, Department of Defense publications, Federal Government publications, General Accounting Office (GAO) studies, books and periodicals. The aim of the literature review was to gain an understanding of LCC principles. This knowledge was utilized in many ways. The LCC information was integrated and presented in Chapter II to provide a background in Life Cycle Costing. The LCC principles were required as a foundation upon which to construct the Modified Graham LCC Decision Model for Non-Major Systems. The LCC knowledge was needed to determine which purchases made by the NRCC, Detachment during the designated time period were valid Life Cycle Costing candidates. Lastly, the LCC information was crucial in determining whether the NRCC, Detachment should purchase non-major systems using Life Cycle Costing techniques.

The second technique for collecting research data was to gather information regarding the contracts awarded by the NRCC, Detachment from 1 January 1990 to 16 January 1992. Tailored computer reports were obtained from the NRCC, Detachment's Automatic Data Processing (ADP) personnel. These listings enabled the researcher to determine which contract awards should be tested in the Modified Graham LCC Decision Model for Non-Major Systems; also, the computer reports provided valuable information on the number, dollar value and type of contracts awarded by the NRCC, Detachment during the designated time period. Additionally, the researcher reviewed the contract folder for each contract award that was selected as a potential LCC candidate. The purpose of this review of the contract folders was to gather the information needed to test a potential LCC candidate in the Modified Decision Model. The final technique of collecting data was the use of telephone and personal interviews. All three groups, contracting personnel, customers and contractors, involved in the contracting process were contacted. These interviews were extremely valuable in gaining an insight into the concerns, problems, capabilities, interests and resources each group had regarding Life Cycle Costing.

E. SCOPE, ASSUMPTIONS AND DEFINITIONS

1. Scope

The scope of this thesis is limited to the contracting activities of the NRCC, Detachment, Long Beach. The study will analyze the usefulness of Life Cycle Costing at a particular field contracting activity. Thus, since the types, dollar value and mix of contract awards vary somewhat from one field contracting activity to another, this study makes no attempt to judge the usefulness of Life Cycle Costing at any contracting activity other than the NRCC, Detachment. However, the Modified Graham LCC Decision Model for Non-Major Systems should be a valuable tool at almost any contracting activity to determine which non-major systems are valid LCC candidates.

Three additional restrictions have been placed on the scope of this thesis. First, since all ADP purchases for both hardware and software made by the NRCC, Detachment already consider Life Cycle Costs, they have been specifically excluded from consideration in this study. [Refs. 31 and 34] Second, the study is primarily interested in analyzing the value of LCC when applied to non-major systems; the term "non-major system" is defined below. Consequently, this research effort makes no attempt to determine the benefits of LCC when applied to the purchase of supplies and services. Finally, the study is limited only to the contracts awarded by the NRCC, Detachment between 1 January 1990 and 16 January 1992. The reason for this restriction is simply that a very large proportion of contracts awarded by the NRCC, Detachment prior to 1 January 1990 have been closed out and the contract folders transferred to the Federal Records Center. [Ref. 31] Thus, the means of collecting the data required for a Life Cycle Costing analysis would not be available for the contracts which have been closed out. Other than these restrictions, this study is not limited to the dollar value of an acquisition, the size of the defense contractor producing the item, or to a specific type of industry.

2. Assumptions

Throughout this thesis, it is assumed that the reader has a working knowledge of the following concepts:

- Department of Defense acquisition concepts and terminology.
- Department of Defense contracting policies and procedures.
- Basic Life Cycle Costing terminology and concepts.
- Field contracting procedures and policies.
- Basic Naval terminology.

3. Definition

For the purpose of this thesis, a non-major system is defined by the researcher as a self-contained device designed to perform a specific task or function. Furthermore, the cost of a non-major system must be less than the minimum procurement cost of $300,000,000 in Fiscal Year 1980 constant dollars required for an item to be classified as a major system as designated in Reference 11. [Ref. 11:p. 15-10] Typical examples of non-major systems purchased by the NRCC, Detachment from 1 January 1990 to 16 January 1992 include: Diesel generator, metal shredder, milling machine, motor, pump, hoist assembly, radar receiver, material handling system, boiler and navigation system.

F. ORGANIZATION OF THE STUDY

This thesis is organized into a total of six chapters. Chapter II is a discussion of the background necessary to fully comprehend the Life Cycle Costing concept. Three key topics will be presented; these are: first, a brief history of Life Cycle Costing is provided; second, the Life Cycle Costing concept, its objectives, use and methodology are discussed; finally, the latent or potential benefits to be gained from the use of Life Cycle Costing are presented.

Chapter III will provide an overview of the Naval Regional Contracting Center, Detachment, Long Beach. Specifically, the mission, history and organization of the NRCC, Detachment will be presented; this is followed by an overview of the contracts awarded by the NRCC, Detachment in Fiscal Years 1990 and 1991.

Chapter IV presents the Graham Life Cycle Costing Decision Model for Spare Parts, its objectives and characteristics. Although the Graham LCC Decision Model was originally intended to be used for the procurement of spare parts, it can be adapted to the acquisition of non-major systems at the NRCC, Detachment. The purpose of modifying the Graham LCC Decision Model is to develop a tool or technique to determine exactly which non-major systems purchased from 1 January 1990 to 16 January 1992 by the NRCC, Detachment are candidates for the Life Cycle Costing concept. Consequently, the second portion of Chapter IV will discuss those modifications necessary to the Graham LCC Decision Model to make it suitable for non-major systems.

Three key points are discussed in Chapter V. First, prior to applying the Modified Graham LCC Decision Model for Non-Major Systems, the method used by the researcher to select the candidates for use in the Model is described. Second, the Modified Decision Model is applied to the candidates selected. The purpose of the application of the Modified Decision Model is to determine which contracts awarded by the NRCC, Detachment from 1 January 1990 to 16 January 1992 were suitable for the use of the Life Cycle Costing concept. Lastly, an analysis of the results of the application of the Modified Decision Model and telephone interviews with the four largest customers of the NRCC, Detachment is presented. The primary goal of this analysis is to determine whether the use of Life Cycle Costing is appropriate for purchasing non-major systems at the NRCC, Detachment.

Finally, Chapter VI provides conclusions of the research, accompanied by recommendations and suggested areas for further research.

II. LIFE CYCLE COSTING: AN OVERVIEW

A. INTRODUCTION

Chapter II is a discussion of the background necessary to fully comprehend the Life Cycle Costing concept. Three key topics will be presented; these are: first, a brief history of Life Cycle Costing is provided; second, the Life Cycle Costing concept, its objectives, use and methodology are discussed; finally, the latent or potential benefits to be gained from the use of Life Cycle Costing are presented.

B. A HISTORICAL PERSPECTIVE

Life Cycle Costing (LCC) is not a new concept.[1] As a major buyer of durable goods, the Department of Defense (DOD) has a long tradition of using LCC and applies this concept to virtually every new major weapon system under development. [Ref. 1:p. 2] As early as 1947, the Armed Services Procurement Regulation (ASPR) implicitly recommended the use of the Life Cycle Costing concept when it stated, ". . . award shall be made to the responsible bidder whose bid will be most advantageous to the Government, price and other factors considered." Of course, "other factors" can be interpreted to include other important considerations such as schedule, quality or Life Cycle Costs.

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[1]Author's note: Like many of the analytical techniques (PERT, CPM, etc.) developed after World War II, little of the history of LCC has been recorded; much of the information provided has been culled from many references.

However, the use of LCC first became formalized and mandated for the DOD in the early 1960's by then Secretary of Defense Robert S. McNamara who served from 1961 to 1968. [Ref. 3:p. 2] McNamara carried with him many ideas and concepts from his extremely successful service at the Ford Motor Company. (He resigned as President of Ford to accept the position of Secretary of Defense.) Two of his key ideas related to LCC were centralized control of procurement and the use of systems analysis or operations research. [Ref. 3:p. 5] This centralization (with the required milestones and decision papers) coupled with systems analysis placed a much greater emphasis on cost estimates and trade-offs between such system attributes as reliability, cost and performance. Although the phrase "Life Cycle Costing" was never used, the genesis of the LCC concept began during McNamara's tenure as Secretary of Defense.

Shortly after McNamara left the DOD, four key documents were written by the DOD which outlined the use of LCC. In 1969, the DOD published DOD Instruction 7041.3 (Economic Analysis and Program Evaluation for Resource Management). U. Cinar calls this "a significant milestone in the establishment of the economic analysis discipline in DOD." [Ref. 14:p. 4] In 1970, the DOD Guide LCC-1 appeared and provided some initial guidelines for the role of LCC analysis in equipment acquisitions. In 1971, DOD Directive 5000.1 was published and firmly instituted LCC analysis as a consideration in the acquisition process for major systems. Later, DOD Directive (DODD) 5000.2 was issued; DODD 5000.2 outlines the requirement to consider total cost, including all ownership costs, at each milestone in the acquisition process. The latest DODD 5000 Series was released in February of 1991 [Refs. 10, 11 and 12]; thus, in the past twenty years the DODD 5000 Series has not only survived but has grown in importance. The disciplined management approach outlined by the DODD 5000 Series has firmly entrenched the LCC concept for major systems.

To summarize, in DOD, LCC analysis began with a vague reference in the ASPR to consider "other factors" in 1947; a quarter of a century later, in 1971, the use of LCC became fully institutionalized as a consideration for each major system acquisition.

The Department of Defense is not alone in its struggle to control Life Cycle Costs. At least seven State Governments have passed laws requiring certain purchases, primarily construction, be made using LCC methodologies. [Ref. 1:p. 3] These States with the corresponding legislation are listed in Figure 1.

In addition to DOD and the State Governments listed in Figure 1, other Federal agencies require the use of LCC. The National Aeronautics and Space Administration (NASA), for instance, is designing the new Space Station using LCC methodologies. [Ref. 18:p. 11] The U.S. General Services Administration (GSA) and the U.S. Department of Energy have worked with the American Institute of Architects to lower the LCC of Federal buildings. [Ref. 1:p. 4] Several NATO nations have adopted the use of LCC; specifically, in the U.K., the Admiralty has required that cost, performance and availability be key attributes of the Design-for-Through-Life Cost (DTLC) technique. [Ref. 14:p. 5] Finally, the private sector has

STATE	LEGISLATION
Alaska	Title 35, Public Buildings, Works and Improvements, 1980 requires development of LCC for public buildings and development of methodologies for the use of LCC.
California	Public Resources Code #25494, 1977, requires preparation of LCC manual by which LCC of building designs could be compared.
Florida	Florida Energy Conservation in Buildings Act, 1974 mandates LCC in building construction for the state.
Maryland	Annotated Code of Maryland, Ch. 597, #78A-256 requires LCC for construction appropriations.
North Carolina	1983 General Statues of N.C. Ch. 143, #143-64.12 requires LCC in construction of state facilities.
Tennessee	Life Cycle Cost and Procurement Act of 1978 requires LCC for purchase of commodities to the extent feasible.
Washington	Code, 1975, Ch. 39.35 requires LCC analysis for any major facility.

Figure 1. State LCC Legislation
[Ref. 1:p. 3]

also recognized the benefit of using LCC. All undergraduate engineering students in their engineering economy courses are instructed the basics of Life Cycle Costing. [Ref. 28:p. 294] The emphasis on fuel efficient automobiles is an example of LCC considerations by car manufacturers.

An excellent summary of the history of LCC is provided by Brown and Yanuck when they state, "LCC: its time has come. Analysis by Life Cycle Costing, therefore, makes economic sense in both the public and private sectors." [Ref. 1:p. 4]

C. THE LIFE CYCLE COSTING CONCEPT

The Life Cycle Costing concept will be outlined and discussed in this section. Specifically, eight areas of LCC will be addressed; each area is critical to gain a full understanding of the LCC concept and how it applies to specific situations.

1. Life Cycle Costing Defined

The Life Cycle Cost of a system is the total cost of ownership of that system over its full life. [Ref. 14:p. 9] In contrast, Life Cycle Costing is the process of using a set of models and techniques to develop a detailed cost estimate of the total lifetime cost of a system. [Ref. 14:p. 9] Quite often ownership costs, such as support or maintenance, far exceed the initial acquisition cost of a system. Consequently, using the lowest bid as a means of selecting a contractor is meaningless if the lowest bid is only defined as initial purchase cost. The lowest bid must also integrate downstream, follow-on costs. Moreover, as the Department of Defense has learned, a low purchase price often leads to high operations and maintenance costs. [Ref. 3:p. 1]

2. The Objectives of Life Cycle Costing

The overall objective of LCC is simply to minimize the total cost of ownership of a particular system. [Ref. 14:p. 9] Typically, this is achieved after careful analysis of design trade-offs of alternative system configurations which fulfill the same system specifications but result in different overall Life Cycle Costs. Since such factors as performance, quality, maintenance, energy consumption and cost are all interdependent, the LCC concept seeks to find that optimal balance of lowest cost between them. [Ref. 14:p. 9] A classical LCC analysis would compare the future benefits of reducing operations costs to the immediate cost of producing the system capable of meeting that future requirement. As Marks and Massey note,

> The major characteristics of these kinds of investment decisions [the use of LCC] is that they are made with the expectation of some sort of tangible payoff--usually in the form of downstream operations and support cost savings, hence a reduction in overall Life Cycle Cost. [Ref. 21:p. 13]

Thus, in order to achieve the objective of the LCC concept, decision makers must choose to accept the required current cost to gain the future benefits of a low LCC system.

3. The Four Life Cycle Phases

Next, a discussion of the term "Life Cycle" is provided. Seldon divides the Life Cycle of a system into four distinct phases. [Ref. 3:pp. 21, 43, 67 and 111] These are the Research and Development Phase, the Production Phase, the Operating and Support Phase and the Disposal Phase. Figure 2 is a graphic representation of how these four are distributed over the life of a system. [Ref. 14:p. 35] Each of the four phases is discussed below:

a. The Research and Development (R and D) Phase includes such areas as determining the mission of the system, producing specifications, providing drawings, developing the prototype, manufacturing planning and customer testing. [Ref. 3:p. 21] Cinar points out that for a typical system ten to fifteen percent of the total LCC is spent during the Research and Development Phase. [Ref. 14:p. 35]

b. The Production Phase consists of all manufacturing related activities that occur between R and D and acceptance of the system. [Ref. 3:p. 43] This phase is the oldest, most used and most developed of the four. Since tremendous efforts are placed in reducing the costs associated with this phase, it is interesting to note that Cinar claims that only twenty-five to thirty-five percent of the total LCC is spent in the Production Phase. [Ref. 14:p. 35]

c. The Operating and Support Phase includes all activities associated with the use of the system. [Ref. 3:p. 67] Specifically, these are items such as training the personnel to use the system, procuring spare parts, preventive and corrective maintenance, energy consumption and so forth. Cinar points out that forty-five to sixty percent of the total Life Cycle Costs are spent during this phase. [Ref. 14:p. 35]

d. The Disposal Phase is the least expensive and the most frequently overlooked phase. Simply put, this phase is the process of transferring ownership from the Government to an individual or a business for salvage or for scrap. [Ref. 3:p. 111] While Cinar points out that the Disposal Phase is roughly five percent of

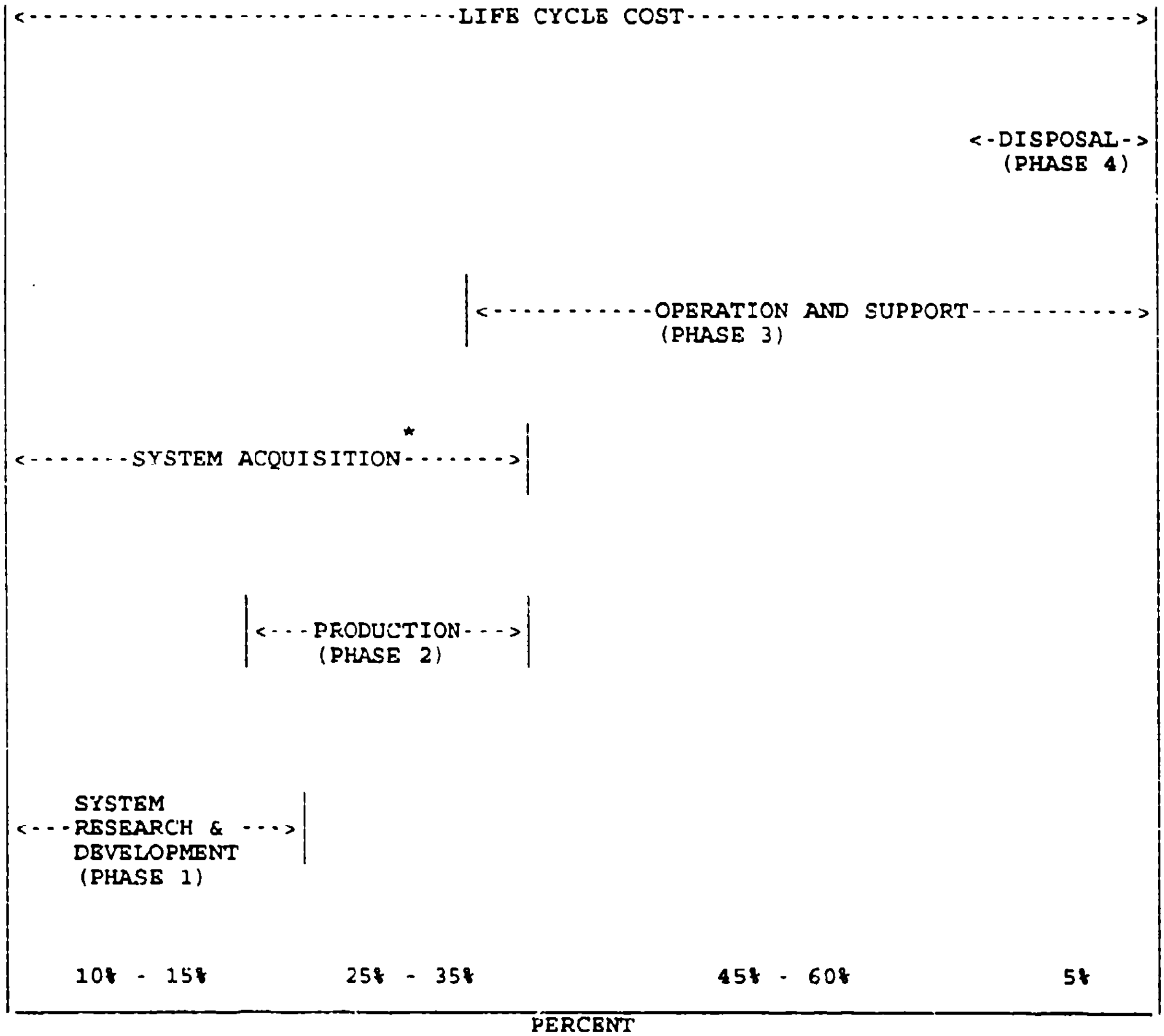

Figure 2. Distribution of System Life Cycle Cost
[Ref. 14 :p. 35]

*System Acquisition is the sum of the Research and Development Phase and the Production Phase.

total LCC [Ref. 14:p. 35], occasionally disposal costs can be quite substantial. For example, consider the great cost of disposing of nuclear power plants or even of concrete structures. Early consideration of the disposal of a system may preclude large, unforeseen costs at the end of a system's service life.

4. When to Use Life Cycle Costing

The Life Cycle Costing process should not be used for every purchase. A Life Cycle Costing analysis adds to the cost of a system. Consequently, LCC analysis should only be conducted when the potential benefits outweigh the costs. Brown and Yanuck have identified four major attributes that a system should have before the LCC concept should be applied to it. [Ref. 1:p. 4] These factors are:

a. Energy Intensiveness: LCC should be considered when the anticipated energy costs of the item are expected to be large throughout its entire Life Cycle.

b. Life Expectancy: For items with long lives, costs other than initial acquisition cost become preponderant. For items with short lives, the initial acquisition cost becomes more important.

c. Efficiency: The efficiency of operation and maintenance may have a large impact on total Life Cycle Cost. LCC is appropriate when savings can be gained through reducing maintenance costs.

d. Investment Cost: As a general rule, the higher the investment the more important LCC analysis becomes.

In addition to the four factors mentioned above, Graham has identified two other factors that should be considered. [Ref. 5:pp. 45-48] These are:

e. Competition: Competition provides contractors with the incentive to meet and exceed minimum requirements at the lowest cost possible. This is especially true, if in its Request For Proposal (RFP), the Government requires the contractors to submit their proposals on a LCC basis in order to be responsive.

f. Mature Design: Only mature technologies or designs have sufficient historical data available to pursue LCC analysis. For instance, the Mean-Time-Between Failure (MTBF) for a developmental electronic device may be entirely unknown, while the failure rate for resistors is easily available.

Perhaps some examples of when to use LCC will clarify what types of purchases are appropriate for LCC analysis. Some assets for which LCC is appropriate include: buildings, construction equipment, automobiles, air conditioning equipment, energy-efficient light bulbs and tires. Some items for which LCC is not appropriate include: furniture, office supplies, detergents, foodstuffs and most paper products.

5. A Generalized LCC Methodology

Cinar has developed a general methodology for LCC that can be tailored to a specific system. [Ref. 14:pp. 20-25] Altogether, Cinar notes eight steps in this methodology; these steps are shown graphically in Figure 3 and are discussed below:

Step 1: State the Objectives

This step defines the scope of the analysis, the accuracy needed, the data required and the cost estimating tools available. This step should also establish a schedule for the LCC analysis and the resources that will be dedicated to the effort.

Step 2: Define the Assumptions

The LCC concept is a method of producing estimates on what will happen to a system in the future. Since data on the future is not known with certainty, all important assumptions must be defined. Typically, assumptions will be defined for such items as the life of the system, operations and maintenance, interest rates and discount rates.

Step 3: Develop a Cost Breakdown Structure

Cinar defines a Cost Breakdown Structure (CBS) as "a hierarchical and logical subdivision of cost by functional activity area, major elements of a system, system components and/or one or more discrete class of items." [Ref. 14:p. 23] In LCC analysis, all cost estimates are derived from the CBS. Also, the cost elements selected should be practical and have sufficient data for analysis.

Step 4: Select a Cost Estimation Tool

Many cost estimation tools are available. These include such techniques as expert opinion, analogy, industrial engineering methods and parametric relationships. Expert opinion is based on the judgment of an individual who is knowledgeable of both the system and its related costs. The major handicap of expert opinion is that it is subjective. Analogy is a means of deriving a new system's cost from historical data of a similar system. This tool is simple and inexpensive to use; however, it is valid only for similar systems. The industrial engineering method is based on a detailed analysis of materials, labor, equipment and overhead costs. The industrial engineering technique is one of the most commonly used cost estimating tools since it is objective and can be substantiated. Finally, parametric tools make use of Cost Estimating Relationships (CER). Cinar states that a CER is "a mathematical relationship that relates the value (in monetary or physical units) of various cost categories to cost generating variables associated with the categories." [Ref. 14:p. 43] Parametric tools are the most commonly used techniques in LCC.

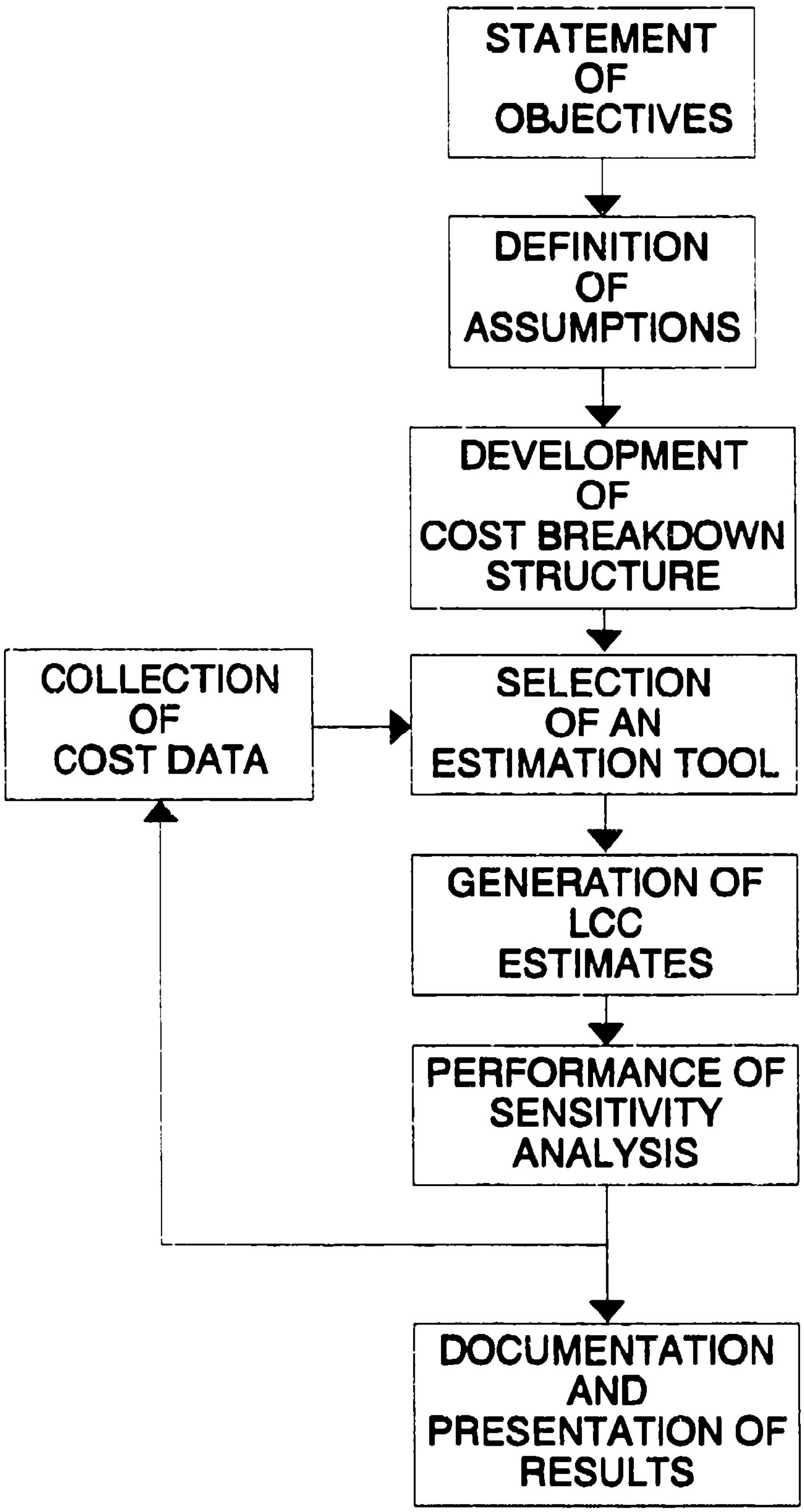

Figure 3. A Generalized LCC Methodology [Ref. 14: p. 22]

[Ref. 14:p. 43] Historical data from prior systems that are similar is absolutely essential to successfully use parametric tools.

<u>Step 5: Collect the Data</u>

While data collection is one of the most important steps in LCC, it is also one of the most difficult as all the required data may not be available. As discussed above, data not available must be estimated and the estimates should be updated as frequently as possible. Naturally, to increase the accuracy of the methodology, the analyst should only use the most current data.

<u>Step 6: Generate the LCC Estimate</u>

After completing the CBS, selecting the cost estimation tool and collecting all data, the analyst can now calculate the total Life Cycle Cost of the system.

<u>Step 7: Perform Sensitivity Analysis</u>

Cinar states that sensitivity analysis is,

> . . . designed to systematically explore the implication of varying assumptions about the environment and is normally centered on the cost drivers where a range of alternative parameters is investigated. [Ref. 14:p. 25]

In other words, the sensitivity analysis is merely a process of changing underlying assumptions to see how they affect the LCC estimate. Of course, more attention should be given to those factors that most greatly affect the LCC estimate to ensure their accuracy.

<u>Step 8: Document the Results</u>

All of the preceding steps should be carefully documented to provide a written record of the LCC analysis and its results.

Moreover, notice that Cinar's LCC methodology is a multidisciplined approach. Very rare is the individual who possesses all the skills necessary to conduct a Life Cycle Costing analysis alone; thus, this task is typically a group effort. Seldon points out thirteen distinct disciplines required to conduct an analysis of Life Cycle Costs. [Ref. 3:p. 17] These skills are listed in Figure 4.

6. A Basic LCC Mathematical Model

A frequent problem in LCC is developing a mathematical model. A simple, elegant yet comprehensive LCC mathematical model that captures the essence of LCC was developed by Dhillon in 1977. [Ref. 2:p. 48] This model was developed for the U.S. Navy to be used in major systems procurement.

In Dhillon's model, Life Cycle Cost consists of five major components. These are: Research and Development Cost (RDC), Operating and Support Cost (OSC), Associated Systems Cost (ASC), Investment Cost (IC) and Termination Cost (TC). Please note that this model matches Seldon's four phases of a system's Life Cycle fairly closely; the primary difference is that Operation and Support costs are broken into several units.

Dhillon's model is shown mathematically below:

$$LCC = RDC + OSC + ASC + IC + TC$$

[Ref. 2:p. 48]

where:

-- LCC denotes total Life Cycle Cost

-- RDC is all research and development related costs

-- OSC is operating and support cost and is made up of the following eight items:

Accounting	Computer Science
Contracting	Estimating
Finance	Industrial Engineering
Logistics	Maintainability Engineering
Management	Manufacturing Engineering
Quality Control	Reliability Engineering
Statistical Analysis	

Figure 4. Disciplines Required for LCC
[Ref. 3:p. 17]

1. Depot supply cost
2. Operating cost
3. Personnel cost
4. Depot maintenance cost
5. Transportation cost
6. Intermediate maintenance cost
7. Sustaining investment cost
8. Installation support cost

-- ASC is all associated systems costs

-- IC is all investment costs and is determined by:

$$IC = PC + GIC$$

where:

-- PC is the procurement cost

-- GIC is the Government's investment cost

-- TC is the termination cost

Some potential problem areas with this, or any, model for LCC should be pointed out. These are:

a. All of the costs listed above are estimates; consequently, the LCC model is no better than the skills available to the Government and the contractor in estimating future costs.

b. As in all mathematical models, the trivial part is building the model. The difficult part is collecting the data to make accurate projections.

c. The time value of money and inflation must not be disregarded. Inflation (or even occasionally deflation) is certain to occur; but no one is certain at what rate inflation will rise. Assuming and planning for a 6% rate of inflation but actually experiencing a 9% rate will quickly destroy the validity of any LCC estimate.

Nevertheless, it should be pointed out that this is a reasonably good model for estimating LCC. However, it is only an estimate; and the projection should be hedged with a high, a most likely and a low estimate. This will allow the analyst, with some certainty, to state what range the LCC should fall between.

7. Resistances to Life Cycle Costing

As alluded to earlier, close attention to LCC can significantly reduce the entire cost of ownership for a given system over its service life. If this is true, then why have relatively few Government acquisitions been contracted on a Life Cycle Costing basis? Seldon points out five factors to explain this resistance to LCC. [Ref. 3:pp. 4-9] These are:

a. Congress provides separate appropriations for the procurement of equipment and the operations and maintenance of that equipment. Furthermore, the end-users and the procurement specialists are very rarely the same people. Thus, the Government provides little institutional incentive for the procurement specialist to pay a higher purchase price for an item in order to obtain reduced operations and maintenance costs. [Ref. 3:p. 4]

b. LCC has encountered strong objections from Congress; they tend to balk at a higher purchase price in order to achieve later, uncertain savings in operations and maintenance. As seen so clearly during the Budget Crisis of 1990, budget constraints are an immediate concern, while the savings resulting from a higher purchase cost will be realized in a distant and uncertain future. [Ref. 3:p. 5]

c. Some past procurement policies resembling LCC have performed poorly. Seldon points out the C-5A transport aircraft program cost overrun, which was purchased using "Total Package Procurement," as a specific example. Total Package Procurement (TPP) only resembled LCC and did not concern itself with the later phases of the Life Cycle. Unfortunately, LCC received the bulk of the criticism regarding TPP. [Ref. 3:p. 6]

d. There are doubts about the accuracy and reliability of data and about the LCC methodology. [Ref. 3:p. 8] The Government has no data accumulated with which to analyze LCC. Also, the Government's procurement specialists lack much of the training required for LCC. As the authors of "Bolstering Defense Industrial Competitiveness" note,

> Department of Defense personnel are not comfortable with the inherently uncertain downstream costs implied in the issues of how reliable a system is and how easily it can be maintained and used, as they are reflected in contractors' projections of requirements for human resources and training, support equipment, spare parts, etc. Even after the fact, the Department has no adequate means to monitor and evaluate actual versus projected Life Cycle Costs and, hence, has no means to gain added confidence in future evaluations of contractors' projections of Life Cycle Costs. One consequence is that the Department of Defense rarely assigns any weight to contractors' reputations for producing reliable, high-quality, low-maintenance systems, because it has little ability to do so. [Ref. 13:p. 51]

e. Contractors are reluctant to guarantee estimates. No contractor can predict the future operations and maintenance cost of a new system to the last penny.

However, contractors can provide their best estimates given certain assumptions about the future. Given that each contractor uses the same assumptions, then the procurement specialist can use these estimates as a means of comparing contractors. [Ref. 3:p. 9]

8. Life Cycle Costing Terminology

In Life Cycle Costing, there is no standard terminology. [Ref. 14:p. 11] However, many terms are used very frequently and they have specific meanings. Thus, a listing of thirty-seven definitions of common LCC terms is provided in Appendix B. This list should prove helpful not only in this thesis but also as a reference.

D. POTENTIAL BENEFITS OF LIFE CYCLE COSTING

The Life Cycle Costing concept has many potential benefits for the Government.[2] The five key benefits of the LCC concept are listed below:

a. The use of LCC is a means of reducing the total cost of ownership of an asset. [Ref. 2:p. 30] The costing data produced from the LCC methodology permits decision makers to: choose the most beneficial procurement strategy, determine the significant cost drivers of a system, make design trade-offs and make source selections. [Ref. 2:p. 30]

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[2]Strangely, most writers on the subject of LCC tend to assume the reader already fully understands the benefits of using LCC. Of course, this may not always be the case.

b. The use of LCC is a means of increasing the reliability of a system. [Ref. 17:p. 6] The reliability of a system is the probability that it will carry out its mission satisfactorily for a prescribed period of time when used according to specified conditions. [Ref. 2:p. 3] The LCC methodology by its very nature considers the future benefits of producing a system that is more reliable. Consequently, beginning with the initial design of the system, engineers are considering such factors as simplification, higher quality materials and components, rigorous testing, and redundancy as means of increasing a system's reliability.

c. The use of LCC can improve a system's maintainability. [Ref. 17:p. 7] This benefit is very closely related to the reliability of a system. Maintainability is the probability that a failed item will be restored to its satisfactory operational state within a specified period. [Ref. 2:p. 3] Moreover, ease of maintenance can be easily and cheaply designed into a system from the outset. As Seldon states,

> The maintainability characteristics of a design are second only to reliability features in driving the costs of the O and S Phase. From a cost point of view failures (reliability) are significant only because they have to be fixed (the purview of maintainability), and that costs money. [Ref. 3:p. 212]

The maintainability of a system can be increased by utilizing the following techniques: using simplification and standardization of design and equipment, increasing accessibility to those components most likely to fail and providing the test equipment used to isolate faults.

d. The use of LCC forces decision makers to plan and act for the long-term vice the short-term. [Ref. 2:p. 11] In the context of LCC, long-term refers to a system's entire Life Cycle, while the short-term focuses entirely on initial acquisition cost. Inherent to the LCC methodology is the idea that the immediate investment in a system that is more reliable, consumes less energy, requires less maintenance or will simply last longer will be richly repaid over the entire Life Cycle of the system. This requires decision makers to plan for the maintenance, operations and support of a system years in advance.

e. The LCC methodology forces the requiring activity or end-user to thoroughly identify its precise needs. [Ref. 14:p. 13] The end-user, assisted by Life Cycle Costing specialists, must determine such system attributes as mission requirements, operational environment, maintenance concepts, design criteria, personnel support and logistics planning. Thus, the LCC methodology requires the end-user to completely describe what is needed, how it will be used and how it will be supported.

E. SUMMARY

This chapter provided a brief overview of Life Cycle Costing. It presented a historical perspective of LCC; the chapter continued by discussing the LCC concept to include: a definition of Life Cycle Costing, the objectives of LCC, the four Life Cycle Phases, when LCC should be used, a generalized Life Cycle Costing methodology, a basic LCC mathematical model, the resistances to LCC and Life Cycle Costing terminology. Finally, the potential benefits of LCC were discussed. Chapter II was intended to give the reader a brief background introduction to the concept of LCC. Chapter III will provide an introduction to the mission, history, organization and purchasing activity of the Naval Regional Contracting Center, Detachment, Long Beach, CA.

III. NAVAL REGIONAL CONTRACTING CENTER, DETACHMENT, LONG BEACH, CA

A. INTRODUCTION

Chapter III will provide an overview of the Naval Regional Contracting Center (NRCC), Detachment, Long Beach, CA. Specifically, the mission, history and organization of the NRCC, Detachment will be presented; this is followed by an overview of the contracts awarded by the NRCC, Detachment in Fiscal Years 1990 and 1991.

B. MISSION

The mission of the Naval Regional Contracting Center, Detachment, Long Beach is as follows:

> The NRCC's mission is to provide field contracting services to those activities in the assigned geographic area and contract for such supplies and services as may be directed by the Commander, Naval Supply Systems Command. The NRCC provides procurement support to Naval shore and fleet units in the Western United States Contracting Region. [Ref. 30:p. 1]

C. HISTORY AND ORGANIZATION

1. History

The history of the NRCC, Detachment, Long Beach is surprisingly complex. The NRCC, Detachment was originally founded in 1943 under the title of Navy Purchasing Office, Los Angeles, CA. [Ref. 30:p. 1] Since 1943 the name has undergone three changes. First, in 1970, the Navy Purchasing Office was renamed the Naval Regional Purchasing Office (NRPO), Los Angeles. Second, in 1973, the NRPO title was abandoned in favor of the Naval Regional Contracting Office (NRCO), Long Beach designation. Finally, in 1982, the name was again changed; on this occasion to the Naval Regional Contracting Center, Long Beach. [Ref. 30:p. 1] Moreover, the mix of commodities and services procured by the NRCC, Detachment has evolved considerably over this 39 year period. [Ref. 30:p. 1] This evolution reflects the broad changes that have also occurred in the Navy Supply System. For example, the responsibility for the procurement of provisions has been transferred to the Defense Logistics Agency. All merchandise purchased for the Navy retail system is now purchased by the Navy Exchange Service Command.

However, the greatest change occurred on 29 May 1987 when the Naval Regional Contracting Center, Long Beach was redesignated the Naval Regional Contracting Center, San Diego. Simply put, the headquarters of the NRCC was transferred to San Diego and the NRCC, Long Beach became a detachment of NRCC, San Diego.

The NRCC, San Diego was formed under the "Contracting Center of Excellence Concept." [Ref. 31] Under this concept, a significant portion of the large purchase (purchases over $25,000) workload on the West Coast was to be consolidated under the command of NRCC, San Diego. The purpose of this structure was to allow the NRCC, San Diego to provide functional management support and policy guidance to all detachments. [Ref. 31] The NRCC, San Diego has major offices at San Diego, CA and Long Beach, CA. Additionally, the NRCC, San Diego has a Resident Office in Melbourne, Australia to assist visiting U.S. Navy vessels.

2. Organization

The organizational chart for the NRCC, Detachment, Long Beach is shown in Figure 5. A description of the organizational chart is provided below. The Officer-in-Charge (OIC) is typically a Supply Corps Commander and is assisted by a Deputy OIC who is normally a GM-14. Altogether, these two managers are responsible for the supervision of approximately 75 contracting specialists and support staff. The Legal Department provides advice to the Procuring Contracting Officers (PCO) and to the contracting specialists regarding contract law. As the title suggests, the Terminations Division is responsible for processing all terminations for default and terminations for convenience. The Support Division provides such services as Automatic Data Processing (ADP) and recordkeeping. The key component of the NRCC, Detachment's organization is the six Contracts Division Branches. [Ref. 31] Each Branch is headed by a GM-14 who acts as the Procuring Contracting Officer; this person has an unlimited warrant. The Branch Head is assisted by a GS-13 who usually has a $1 million warrant. Four of the six Branches are assigned responsibility for the NRCC, Detachment's major customers. [Ref. 31] The four customers are as follows:

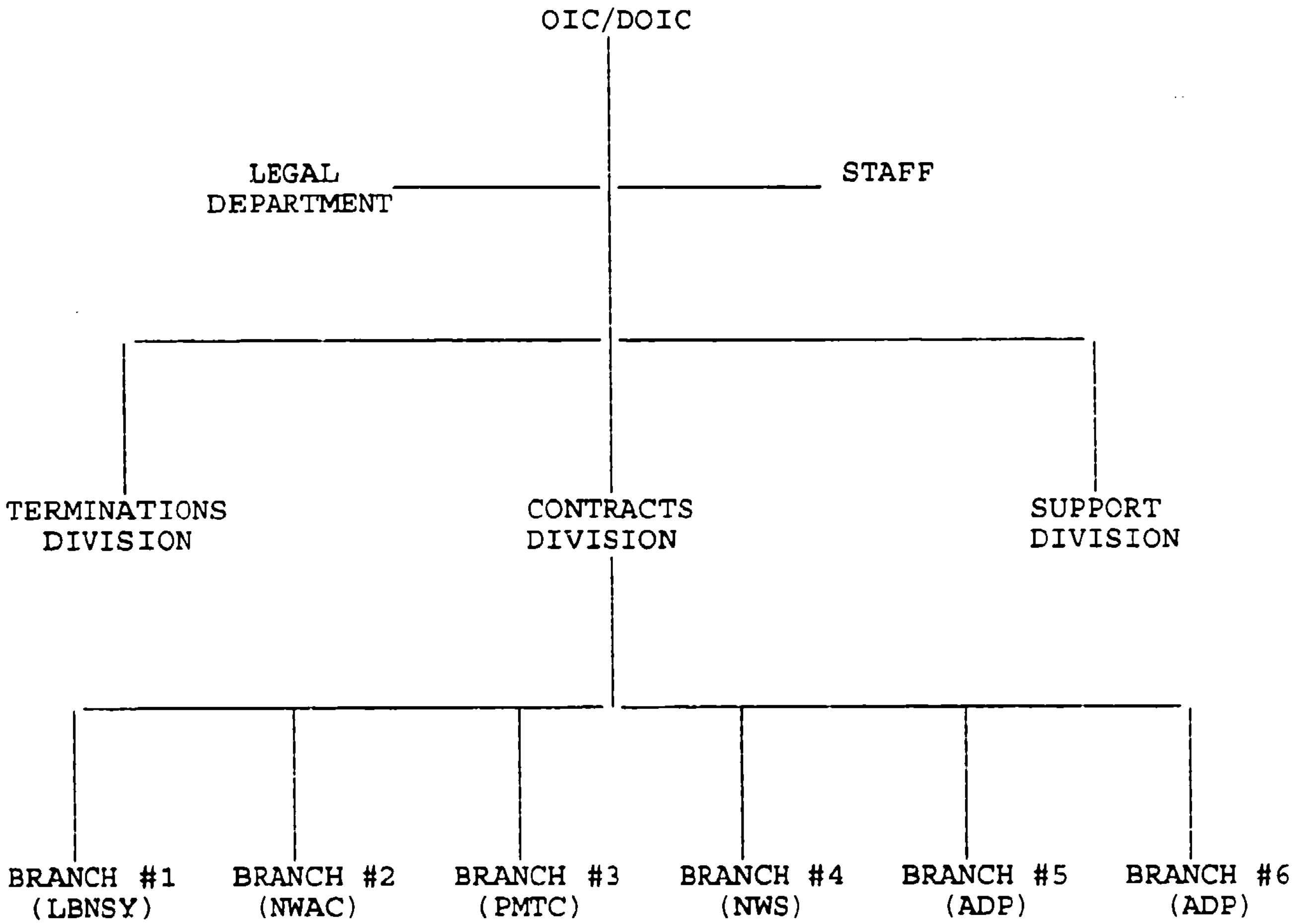

Figure 5. Organizational Chart for the NRCC, Detachment, Long Beach, CA. [Ref. 31]

Long Beach Naval Shipyard (LBNS), Long Beach, CA; Naval Warfare Assessment Center (NWAC), Corona, CA; Pacific Missile Test Center (PMTC), Point Mugu, CA; and Naval Weapons Station (NWS), Seal Beach, CA. The remaining two Branches purchase ADP equipment and services; a major requiring activity of ADP equipment and services is the Naval Postgraduate School (NPS), Monterey, CA.

D. OVERVIEW OF CONTRACTS AWARDED IN FISCAL YEARS 1990 AND 1991

This section is intended to provide the reader with an overview of the magnitude and the breakdown of the types of contracts awarded by the NRCC, Detachment. The information used in this section is derived from a computer listing generated by the NRCC, Detachment ADP personnel on 17 January 1992. The computer listing summarizes all contracts awarded by the NRCC, Detachment for Fiscal Years (FY) 1990 and 1991. The listing contains the following data elements:

- Schedule Number
- Procurement Item Identification Number (PIIN)
- Document Number
- Contractor
- Description
- Date Executed
- Estimated Value of Contract
- Negotiated Amount of Contract
- Federal Supply Code (FSC)

The data supplied in the computer listing is summarized in Table 1.

TABLE 1

SUMMARY OF CONTRACTS AWARDED BY THE NRCC, DETACHMENT, LONG BEACH, CA FOR FISCAL YEARS 1990 AND 1991

	Fiscal Year 1990		
	Supplies	Services	Total
Number of Contracts Awarded	194	280	474
Percentage of Total	40.9%	59.1%	100%
Dollar Value of Contracts Awarded (in Thousands of Dollars)	$62,679	$229,599	$292,278
Percentage of Total	**21.4%**	**78.6%**	**100%**
	Fiscal Year 1991		
	Supplies	Services	Total
Number of Contracts Awarded	180	277	457
Percentage of Total	39.4%	60.6%	100%
Dollar Value of Contracts Awarded (in Thousands of Dollars)	$70,658	$523,801	$594,459
Percentage of Total	**11.9%**	**88.1%**	**100%**

TABLE 1 (CONTINUED)

	Fiscal Year 1990		
	Supplies	Services	Total
Combined Dollar Value of Contracts Awarded in FY 1990 and 1991 (in Thousands of Dollars)	$133,337	$753,400	$886,737
Combined Percentage of Total	**15.0%**	**85.0%**	**100%**

The data in Table 1 reveal three points concerning the contracts awarded by the NRCC, Detachment over this two year period. First, approximately 85% of all contracts awarded, in dollar terms, is for services. This is supported by the following comment by the OIC, "About 75% of all our business is large service contracts." [Ref. 31] However, the percentage of the number of contracts awarded is not as heavily in favor of service contracts. Roughly 60% of the number of contracts awarded during this two year period were for service contracts. Moreover, this six to four ratio of the number of service contra to supply contracts was virtually constant over the two year period. Second, the average size of a service contract over this two year period is quite large. The average size of a service contract is $1.35 million, while the average size of a supply contract is $356,000. Moreover, the OIC points out that none of the contracts awarded during this period was a small purchase (a contract for less than $25,000), as the NRCC, Detachment does not process any small purchases for its customers. [Ref. 31] The NRCC, Detachment's customers all have small purchase authority. [Ref. 31] Naturally, this lack of small purchase activity helps keep the average dollar value of contracts awarded fairly large. Third, the data in Table 1 show that while the dollar value of all contracts awarded increased significantly in FY 1991, the number of contracts awarded was virtually constant. This indicates that while the dollars involved may have increased dramatically, the workload on the contracting specialists was somewhat constant.

E. SUMMARY

Chapter III was an overview of the Naval Regional Contracting Center, Detachment, Long Beach. The mission, history and organization were all discussed. This was followed with an overview of the contracts awarded by the NRCC, Detachment in FY's 1990 and 1991. Chapter IV will introduce and describe the Graham LCC Decision Model for spare parts; this will be followed by a discussion on how the Graham LCC Decision Model may be modified such that Procuring Contracting Officers can apply it to the acquisition of non-major systems at the NRCC, Detachment.

IV. THE MODIFIED GRAHAM LIFE CYCLE COSTING DECISION MODEL

A. INTRODUCTION

Chapter IV presents the Graham Life Cycle Costing Decision Model, its objective and characteristics. Although the Graham LCC Decision Model was originally intended to be used for the procurement of spare parts, it can be adapted to the acquisition of non-major systems at the NRCC, Detachment, Long Beach. The purpose of modifying the Graham LCC Decision Model is to develop a tool or technique to determine exactly which non-major systems purchased from 1 January 1990 to 16 January 1992 by the NRCC, Detachment are candidates for the LCC concept. Consequently, the second portion of Chapter IV will discuss those modifications necessary to the Graham LCC Decision Model to make it suitable for non-major systems.

B. THE GRAHAM LCC DECISION MODEL

In June 1988 Ruth Graham, Lieutenant, Supply Corps, U.S. Navy, presented her thesis titled "Life Cycle Costing in Spare Parts Procurement: A Decision Model." [Ref. 5] In this thesis, Graham developed an excellent qualitative decision model intended to be used to identify those spare parts which lend themselves to the use of Life Cycle Costing.

1. Objective

The objective of the Graham LCC Decision Model is to " . . . provide contracting officers with a simple mechanism for determining if Life Cycle Costing methods should be applied to some specific spare part." [Ref. 5:p. 7] This is an important point. Given that every purchase is not a LCC candidate (see Chapter II) and that the LCC analysis increases the cost of a particular item, then the contracting officer and the requiring activity must have some criteria by which to decide if an item is a viable candidate for LCC. The Graham Decision Model provides just such a method for spare parts.

2. Characteristics

Graham identified nine characteristics of spare parts that determine whether the item should be purchased using Life Cycle Costing. [Ref. 5:p. 42] The Graham LCC Decision Model and its nine characteristics are displayed graphically in Figure 6. The characteristics are:

-- Urgency of Requirement

-- Shelf Life Constraints

-- Availability on the Open Market

-- Maturity

-- Total Procurement Cost

-- Durability

-- Technical Data Considerations

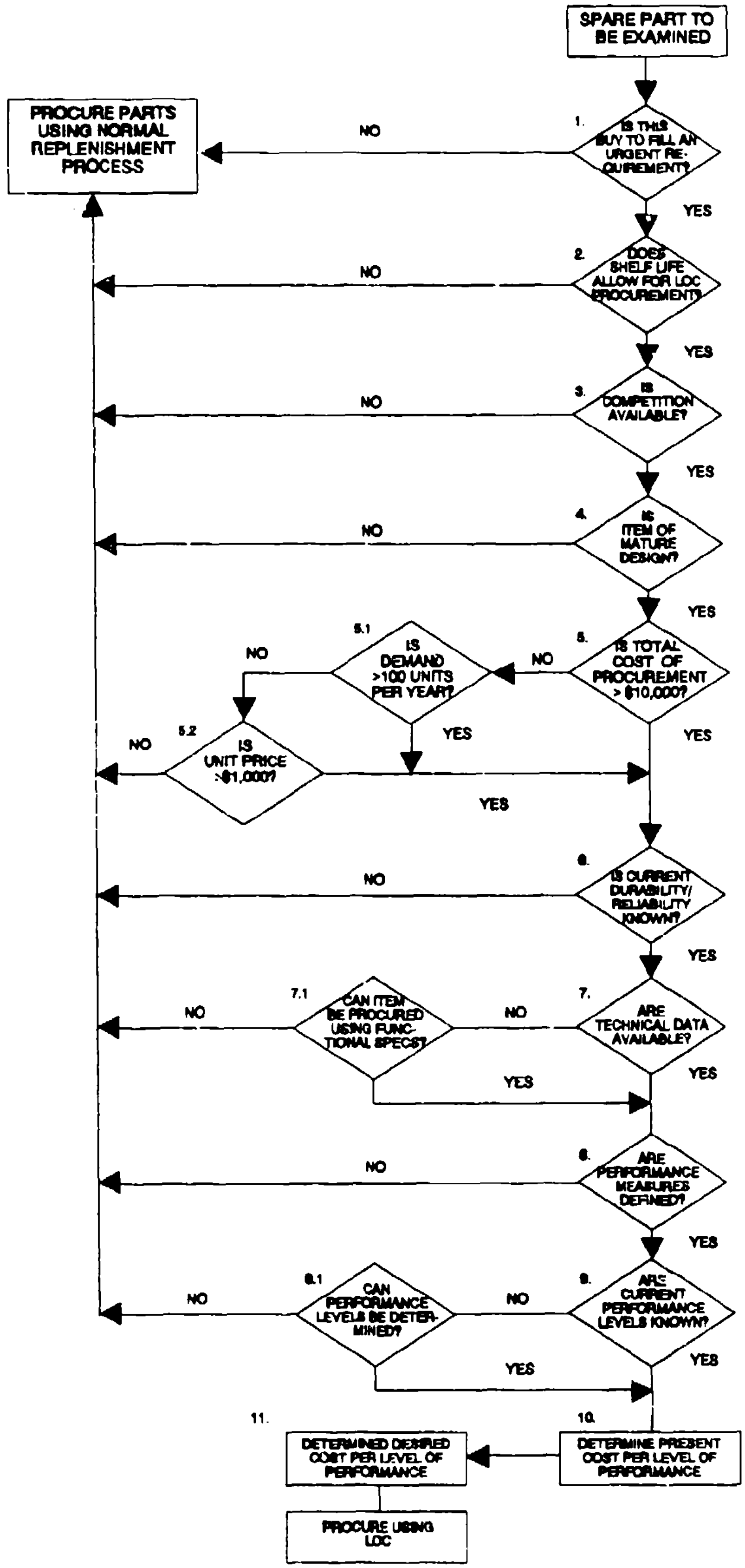

Figure 6. The Graham Decision Model for Spare Parts [Ref. 5: p. 4]

-- Performance Measures

-- Performance Levels

These nine characteristics will be discussed in detail below; however, prior to that, two key points should be addressed. First, the order of consideration of the characteristics of the Graham LCC Decision Model is significant. As Graham points out,

> The researcher has determined that the most effective order of consideration for the chosen spare part characteristics is from that characteristic most clearly defined and easiest to identify to that characteristic most difficult to define and identify. [Ref. 5:p. 42]

Thus, the user of the Graham LCC Decision Model can quickly disqualify those items which are not obvious candidates. For instance, an item that is an urgent requirement from a sole source contractor can be rejected as a candidate for LCC with little effort. Furthermore, as the Decision Model proceeds to the characteristics that are more difficult to determine, the user has fewer candidates to analyze and is not overburdened with reviewing all the original candidates. [Ref. 5:p. 43] Second, as can be gathered in Figure 6, each characteristic corresponds to a decision point in the flow chart of the Graham LCC Decision Model. Also, each decision point requires a simple "Yes" or "No" response to determine if the item meets the requirements of that particular characteristic. With the exception of the first characteristic, a negative response eliminates the item as a candidate for LCC. In contrast, a series of all favorable responses results in a determination that the item should be procured using Life Cycle Costing.

The nine characteristics of the Decision Model are discussed below. Notice that each characteristic has a decision number listed; this is to assist the reader in determining where the characteristic is positioned in the Graham LCC Decision Model displayed in Figure 6.

a. Urgency of Requirement (Decision Number 1)

The first step in the Decision Model is to determine the time frame in which the item is needed. Graham estimates that the process of applying the Decision Model, collecting the required data and implementing the contracting steps of solicitation, proposal, negotiation, award and delivery will consume at least six months. [Ref. 5:p. 46] Consequently, if an item is an urgent requirement, then the use of Life Cycle Costing is not appropriate. However, if at least six months are available for procurement, then the user should continue to the second step.

b. Shelf Life (Decision Number 2)

This characteristic is simply how long the spare part can be stored in inventory prior to use. [Ref. 5:p. 40] Thus, if the item has a very short shelf life, defined by Graham as less than six months, then LCC is inappropriate. [Ref. 5:p. 46] However, if the shelf life is greater than six months, then continue to step 3. As discussed later in this chapter, shelf life is not a consideration when purchasing non-major systems at the NRCC, Detachment; therefore, the shelf life characteristic will be dropped from the modified Graham LCC Decision Model.

c. **Availability on the Open Market (Decision Number 3)**

The third characteristic deals with the availability of competition. [Ref. 5:p. 46] As Graham points out,

> The researcher believes that, to make Life Cycle Costing techniques effective, competition is essential. Competition will provide contractors with the incentive to meet and exceed minimum criteria at the lowest cost possible. [Ref. 5:p. 47]

If the item can be purchased from more than one source, then continue to the fourth step. If not, then use normal purchasing procedures.

d. **Maturity (Decision Number 4)**

The fourth step determines whether the item is mature or state-of-the-art. [Ref. 5:p. 47] Graham comments,

> The researcher contends that a state-of-the-art item will tend to be too complex for Life Cycle Costing techniques. State-of-the-art spare parts tend to have insufficient historical data on them to determine actual durability or performance levels and engineering estimates . . . will contain substantial error. As a result, the user should stick to parts of mature design. [Ref. 5:p. 47]

Accordingly, if the item is of mature design, then continue to the next decision characteristic. If not, then procure using normal contracting procedures.

e. **Total Procurement Cost (Decision Numbers 5, 5.1 and 5.2)**

The added benefit of using Life Cycle Costing must more than offset the added cost of the LCC analysis in order to make the effort worthwhile. Typically, this holds true only for relatively expensive items. [Ref. 1:p. 4] Thus, Graham included total procurement cost as the fifth decision characteristic. [Ref. 5:p. 48] Graham arbitrarily selected $10,000 as the dollar value threshold; because of the arbitrary nature of this dollar amount, Graham included two additional criteria. [Ref. 5:pp 48-49] The first is the demand for the item. Demand is simply how often and in what quantity an item is required. [Ref. 5:p. 48] Graham selected a demand that is greater than 100 units per year as the point where the extra cost of analysis is offset by the LCC benefits. [Ref. 5:p. 48] The second criterion is the unit price of the item, for which Graham selected a price of $1,000. As can be gathered from Figure 6, an item can meet any of three criteria (total procurement cost, quantity demanded or unit price) in order to continue to the next decision characteristic. In the Modified Graham LCC Decision Model, this decision characteristic is significantly revised and simplified.

f. Durability (Decision Number 6)

The sixth step is to test the durability of the item. [Ref. 5:p. 49] Graham uses the term "durability" to refer to the effective life of the item; effective life can be defined as the probability that an item will perform satisfactorily for a specific period of time under given conditions.

[Ref. 5:p. 39] As Graham notes,

> To continue with this model, the user must know what the "effective lifetime" is. The effective life may be defined in the specifications for the item in question, or may be available in maintenance records, or can be determined by engineering personnel. [Ref. 5:p. 50]

Therefore, if the durability or effective life of the item cannot be determined, then the item should be procured using normal contracting procedures. If the effective life can be determined, then proceed to the seventh step. This decision characteristic is altered in the Modified Graham LCC Decision Model.

g. **Technical Data (Decision Numbers 7 and 7.1)**

The seventh step is to determine the availability or necessity of technical data. [Ref. 5:p. 50] Graham identifies two sets of technical data considerations. First, is the concept of form, fit and function. [Ref. 5:p. 36] Simply, this concept uses functional requirements to outline such attributes as size, configuration or performance of the item. As Graham notes,

> Each contractor under a form, fit and function procurement has total freedom of internal design. Detailed technical data packages are not needed for these types of procurements. A functional specification will suffice. [Ref. 5:p. 36]

Second is the concept of a detailed technical data package. [Ref. 5:p. 36] This type of package is required under such circumstances when the item is very complex, it cannot be specified in functional terms or is limited to a standardized design. [Ref. 5:p. 36] Graham states,

> The technical data package specifies how to build the item. It details internal, as well as, external design. The result is a spare part virtually identical to the original part being replaced. [Ref. 5:p. 37]

If technical data are available, then the user should continue to step eight. However, if such data are not accessible, then the user should determine whether form, fit or function specifications are available or can be developed; if so, then proceed to the eighth step. Otherwise, the item should be bought using standard contracting procedures.

h. **Performance Measures (Decision Number 8)**

Performance Measures are, in plain terms, the quantifiable units of output for a particular item. Several examples of performance measures include such measures as: work output per energy input (miles per gallon), mean-time-to- failure (days or hours to failure), mean-time-to-repair (hours to repair) or operational performance (miles per hour). [Ref. 5:p. 51] If performance measures are defined or can be defined, then the user should proceed to the next step. However, if performance measures are unknown or cannot be defined, then standard contracting methods should be used to acquire the item.

i. Performance Levels (Decision Number 9)

Step nine is the final decision characteristic of the Graham LCC Decision Model. For the items that have survived the previous eight decision characteristics, the user should now calculate or determine the current level of performance. [Ref. 5:p. 51] Graham identifies performance levels as the specific amount of units of output for a particular item. [Ref. 5:p. 38] Examples of performance levels include such terms as 18 miles per gallon, 350 hours to failure, 55 miles per hour or 1,500 flight hours. Graham points out the great importance of current performance levels when she states,

> Determining the current performance level is important because, to apply Life Cycle Costing methods to minimize the cost per level of performance, the user must know what the current level is, so that higher levels can be set as a goal for future procurements. [Ref. 5:p. 51]

Consequently, if the procurement performance level is known or can be determined from maintenance records or through engineering estimates, then the item is a candidate for LCC. The user should now continue to step ten. If the current level of performance is unknown or cannot be calculated, then the item should be purchased using routine procedures.

By successfully meeting each of the previous nine decision characteristics of the Graham LCC Decision Model, the item is now a definite candidate for the Life Cycle Costing technique. At this point in the Decision Model, Graham inserted two final steps, which are numbers ten and eleven in Figure 6. The first of these requires the user to determine or calculate the current cost per level of performance. [Ref. 5:p. 52] The cost per level of performance is calculated by simply dividing the unit cost of the item by the performance level. [Ref. 5:p. 52] For instance, given that the unit cost of a spare part is $10,000 and the current performance level is 1,000 hours to failure, then the cost per level of performance is $10 per hour. As discussed later in the chapter, this step is eliminated from the Modified Decision Model.

The final step, step eleven, is to determine the desired cost per level of performance. [Ref. 5:p. 53] According to Graham, the purpose of determining the cost per level of performance is twofold. [Ref. 5:p. 53] The first purpose is to permit the contracting officer to understand the end user's requirement so that accurate and clear requirements can be included in the solicitation document. The second purpose, according to Graham, is to use the desired cost per level of performance as a selection criterion for selecting the successful contractor. [Ref. 5:p. 53] As Graham states, "For clarity sake, the solicitation must clearly state whether the cost criterion is a maximum or simply a goal and it must define the acceptable standard deviation." [Ref. 5:p. 53] In this manner, the contractor is keenly aware of what is required with little ambiguity. As discussed below this step is eliminated when the Graham LCC Decision Model is modified for use at the NRCC, Detachment.

To recapitulate, this section described the Graham LCC Decision Model; the Model was developed to provide contracting officers a tool to select those spare parts which are valid candidates for procurement using Life Cycle Costing. Additionally, the objective and characteristics of the Decision Model were discussed in detail.

C. THE MODIFIED GRAHAM LCC DECISION MODEL

Although Graham originally intended the Decision Model to apply to spare parts, with relatively few modifications, it can be altered to provide a useful tool for selecting those non-major systems purchased by the NRCC, Detachment, Long Beach which are viable candidates for Life Cycle Costing. The writer has selected the name "The Modified Graham LCC Decision Model for Non-Major Systems" for the altered Graham Decision Model. This provides full credit to Graham for originating the concept, format and key ideas of the Decision Model.

1. Objective

The objective of the Modified Graham LCC Decision Model is to provide a means for contracting officers and managers at the NRCC, Detachment to select those non-major systems that are likely Life Cycle Costing candidates. During interviews and research at the NRCC, Detachment, the researcher has determined that there is no formal method or attempt to procure non-major systems using LCC considerations at the NRCC, Detachment. [Ref. 31] Of course, all ADP acquisitions at the NRCC, Detachment consider Life Cycle Costs [Refs. 31 and 34]; but ADP purchases have been excluded from the scope of study in this thesis. Thus, the Modified Graham LCC Decision Model can, at least, assist contracting officers and managers identify those purchases for which LCC methodologies can be applied.

2. Modifications

The Modified Graham LCC Decision Model is displayed graphically in Figure 7. Notice that the Modified Decision Model has virtually the same decision format as the original. With the exception of the first decision, an affirmative response allows the user to continue to the next decision characteristic. Only individual characteristics have been altered.

In order to provide the reader with a clear understanding of the specific changes made to the original Decision Model, Table 2 is provided. Table 2 lists the steps of the original Graham LCC Decision Model for Spare Parts, the modifications made to it and the steps of the Modified Graham LCC Decision Model for Non-Major Systems.

3. The Modified Decision Model

Each decision characteristic shown in Figure 7 of the Modified Graham LCC Decision Model for Non-Major Systems is described below.

a. Urgency of Requirement (Decision Number 1)

This characteristic is identical to the urgency of requirement decision discussed in the original Graham LCC Decision Model.

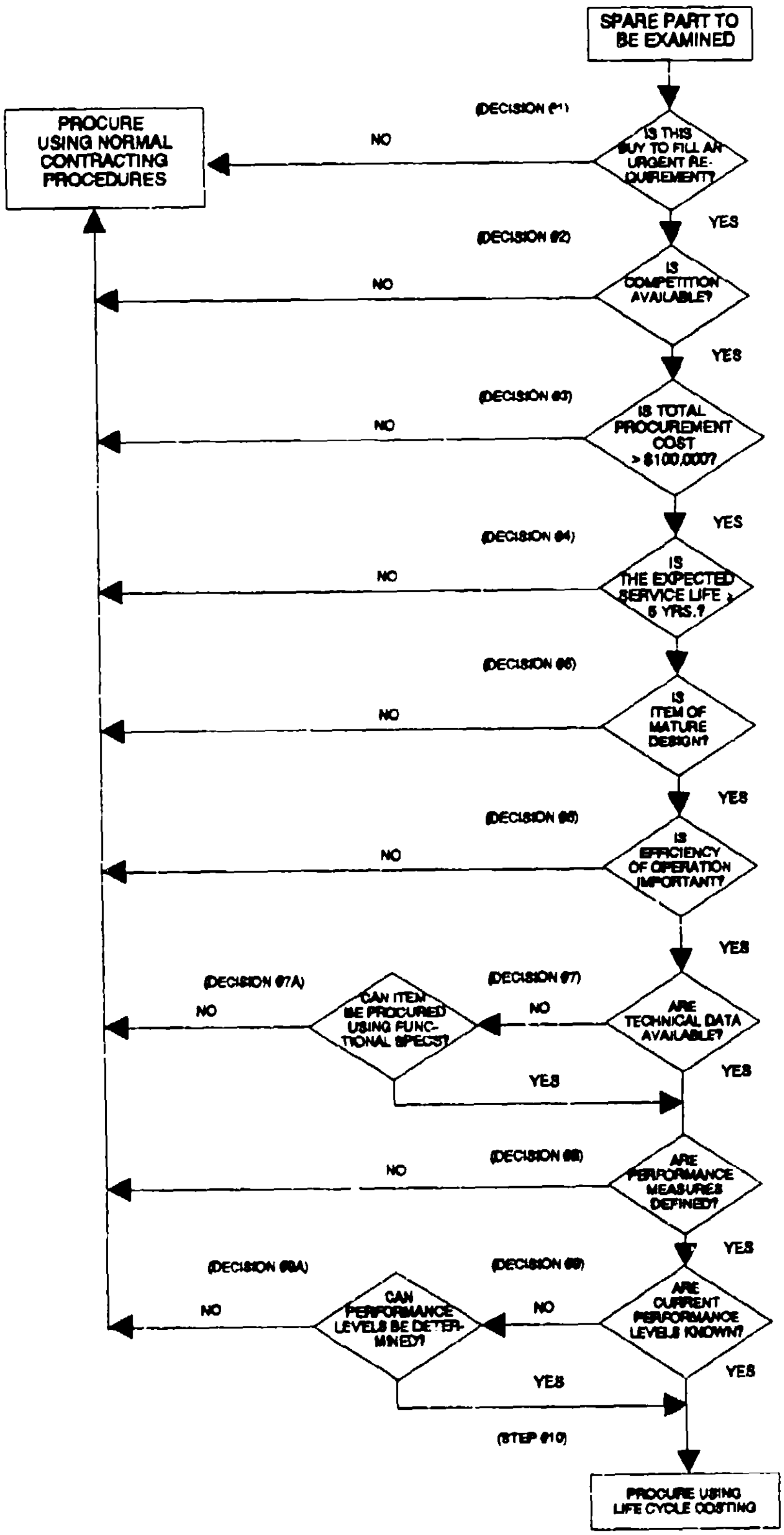

Figure 7. The Modified Graham LCC Decision Model

TABLE 2

SUMMARY OF CHANGES MADE TO THE GRAHAM LCC DECISION MODEL FOR SPARE PARTS

Original Graham LCC Decision Model for Spare Parts	**Modifications to Original Model**	**Modified Graham LCC Decision Model for Non-Major Systems**
Decision #1: Urgency of Requirement	None	Decision #1: Urgency of Requirement
Decision #2: Shelf Life	Deleted	Decision #2: Availability on the Open Market
Decision #3: Availability on the Open Market	Moved to Decision #2	Decision #3: Total Procurement Cost
Decision #4: Maturity	Moved to Decision #5	Decision #4: Expected Service Life
Decision #5: Total Procurement Cost	Moved to Decision #3 and Altered	Decision #5: Maturity
Decision #6: Durability	Moved to Decision #4 and Altered	Decision #6: Efficiency of Operation
Decision #7: Technical Data	None	Decision #7 Technical Data
Decision #8: Performance Measures	None	Decision #8: Performance Measures
Decision #9: Performance Levels	None	Decision #9: Performance Levels

TABLE 2 (CONTINUED)

Original Graham LCC Decision Model for Spare Parts	**Modifications to Original Model**	**Modified Graham LCC Decision Model for Non-Major Systems**
Decision #10: Cost Per Level of Performance	Deleted	
Decision #11: Deleted Desired Cost Per Level of Performance	Deleted	

b. Availability on the Open Market (Decision Number 2)

This characteristic is also identical to the availability of competition decision as described in the original Decision Model. As noted in Table 2, this characteristic was moved from Decision Number 3 in the original Decision Model to Decision Number 2 in the Modified Decision Model. This was done simply because the second decision, shelf life, was eliminated from the Modified Decision Model.

c. Total Procurement Cost (Decision Number 3)

As noted earlier, Graham arbitrarily selected $10,000 as the dollar threshold for the minimum procurement cost. A more logical approach would be to use the $100,000 threshold as originally established in the Truth in Negotiations Act (TINA) of 1962 (Public Law 87-653). Briefly, TINA requires accurate, current and complete cost or pricing data as of the date the price agreement was reached for specific situations outlined in the Federal Acquisition Regulation (FAR) which are expected to exceed $100,000. [Ref. 8: Subpart 15.804-2] Although the 1991 Defense Authorization Act (Public Law 101-510) raised the TINA threshold to $500,000 for defense contracts, the $100,000 threshold is valid for two important reasons. First, this amount represents a sizeable investment in both absolute terms and in relative terms to the customers of the NRCC, Detachment. [Ref. 31] As mentioned earlier, Brown and Yanuck specifically designated that the degree of investment cost is a key factor in determining if the LCC analysis is feasible. [Ref. 1:p. 4] Second, despite being less than the current TINA threshold, $100,000 is a high enough threshold to disqualify those non-major systems that simply do not represent a significant proportion of the Government's resources. By eliminating those purchases under $100,000, the contracting officer can focus his attention on those non-major systems that will provide the greatest return for his efforts. Perhaps an example can clarify this point. Assume that through LCC analysis the Government can save in operating and maintenance costs an amount equal to 15% of the purchase price of the non-major system. Also assume that this applies to two distinct non-major systems, Item A which costs $100,000 and Item B which costs $35,000. Thus, the savings to the Government for Item A is $15,000, while for Item B it is only $5,250. Consequently, the contracting officer should focus his attention on the higher priced item given these particular circumstances. This relationship also holds true in general; as Brown and Yanuck point out, "As a general rule, the larger the investment, the more important LCC analysis becomes." [Ref. 1:p. 4]

This characteristic was moved above the maturity characteristic because the dollar threshold is easier to determine than whether an item is of mature design or is state-of-the-art. As discussed earlier, the more straight forward characteristics should be decided upon first. This enables the user to quickly and easily eliminate those items that are not obvious LCC candidates.

d. Expected Service Life (Decision Number 4)

Graham uses the term "durability" to mean the effective service life of an item. In the original Decision Model, if the effective life of an item could be determined, then it met the criteria to continue through the decision process. However, this decision regarding durability in the original Decision Model is somewhat vague. Therefore, in the Modified Decision Model the durability decision has been replaced with an expected service life decision. In the Modified Decision Model, an expected service life of greater than or equal to five years has been selected. If the non-major system has an expected service life of at least five years, then continue to decision number five. If not, then reject the item as a LCC candidate.

The five year period was selected because a lengthy period of time will be required to realize the benefits of procuring an item using LCC. As discussed in Chapter II, the LCC concept is used with the expectation of recouping the additional up-front costs of procuring an item with improved reliability, reduced operating costs or reduced energy consumption over the service life of the item. A minimum of five years appears to be a reasonable length of time to achieve this goal. Furthermore, this period of time is reinforced by the Accelerated Cost Recovery System (ACRS) used to calculate asset depreciation for Federal tax purposes. In his book, Managerial Accounting, Garrison provides multiple examples of which types of assets fall into which property class (i.e., three year property class, five year property class, seven year property class, etc.). [Ref. 32:p. 700] The five year property class is the first to identify likely LCC candidates. Garrison includes such non-major systems as automobiles and light trucks, duplicating equipment, heavy general purpose trucks, copiers and research equipment as examples of assets included in the five year property class. [Ref. 32:p. 700] For these reasons, in the researcher's opinion, at least a five year service life is required to justify purchasing a non-major system using LCC.

e. Maturity (Decision Number 5)

Although moved from decision number four to decision number five, this decision characteristic is identical to the maturity of design characteristic discussed in the original Decision Model.

f. Efficiency of Operation (Decision Number 6)

Efficiency of operation refers to those system attributes that allow the system to perform its designated task in the most efficient manner. Four specific system attributes that can improve a system's efficiency are as follows: First, is energy consumption a consideration? Naturally, systems, such as boilers or automobiles, that are energy efficient tend to have lower Life Cycle Costs. Second, is ease of maintenance important? Ease of maintenance is simply how easily and quickly can a failed system component be repaired or replaced. This will particularly apply to complex systems with many subassemblies or components. Third, is reliability a key consideration? Reliability can be defined as the frequency of corrective maintenance; this will apply to systems that are difficult or expensive to repair. Finally, is simplicity of operation important? The training and use of personnel to operate a system can be a large percentage of total Life Cycle Costs; therefore, a system that is simple to operate should require less highly trained and less skilled operators. This, too, will tend to reduce total LCC. If efficiency of operation is important, then proceed to the next step. If not, then procure the item using normal contracting procedures.

g. Technical Data (Decision Number 7)

The availability of technical data decision is the same in the Modified Decision Model as in the original Decision Model.

h. Performance Measures (Decision Number 8)

This decision characteristic is identical to the one in the original Decision Model.

i. Performance Levels (Decision Number 9)

The determination of performance levels is the same as outlined in the original Decision Model.

4. Deleted Characteristics

The three decision characteristics which were deleted from the original Graham LCC Decision Model will now be discussed.

a. Shelf Life

The shelf life characteristic applies only to spare parts and not to non-major systems. Consequently, this characteristic has been deleted from the Modified Decision Model.

b. Cost Per Level of Performance

As discussed earlier in this chapter, Graham defined the cost per level of performance as the result of dividing the unit cost of the spare part by the performance level. [Ref. 5:p. 52] For spare parts, which by definition are discrete subunits of a system, this is a relatively simple dollar amount to calculate. However, the cost per level of performance for a non-major system is much more difficult to determine. As pointed out in Chapter II, Dhillon's LCC Mathematical Model shows that the Life Cycle Cost of a system is the sum of the research and development cost, operating and support cost, associated systems cost, investment cost and termination cost. The simplistic approach of dividing the initial unit cost by the level of performance to determine cost per level of performance simply will not be accurate for non-major systems. In the researcher's opinion, a more logical approach for non-major systems would be to have the potential contractors submit their estimates of LCC for the item in their proposals. This could be achieved by specifically requiring the contractors to submit this LCC information in the Request For Proposal.

c. Desired Cost Per Level of Performance

The final step in the original Decision Model has been deleted in the modified version. The reasoning for this deletion is that the desired cost per level of performance is, in the writer's opinion, a nebulous number to decide upon. Who determines the desired cost per level of performance? Graham avoids answering this important question. The logical choice is the customer; however, the customer may not have the expertise, ability or information necessary to calculate a desired cost per level of performance. A more practical approach is to allow the market place to ultimately determine the cost per level of performance. Given that this model requires competition and that competition drives the price of an item to an optimal level, then the cost per level of performance resulting from a LCC purchase should be as reasonable as can be expected.

D. THE FINAL STEP: PROCURE USING LCC

The final step, step ten, in the Modified Graham LCC Decision Model for Non-Major Systems states, "Procure Using Life Cycle Costing." This simple phrase requires explanation. In order to procure an item using LCC, at least four key points must be addressed. These are: the contracting officer is the key person in the LCC effort; the customer's participation is essential; the Request For Proposal (RFP) must be carefully crafted to specify the use of LCC; and the contractors must fully understand exactly what is required of them. Each of these key points is discussed in greater detail below.

1. The Key Person

A natural question arises as one reads the earlier discussion on the Modified Decision Model. This question is, who is responsible for determining which non-major systems under purchasing consideration by the NRCC, Detachment are LCC candidates? Or stated differently, who applies the Modified Graham LCC Decision Model? The OIC of the NRCC, Detachment suggests that the Procuring Contracting Officer (PCO), as with so many other important contracting issues, is the key person in this process. [Ref. 31] Thus, the PCO should be responsible for coordinating the efforts of using LCC. No other individual is in the unique position to be able to communicate with the potential contractors, the engineering specialists and the customer. Simply put, the PCO should act as the "clearinghouse" for all the information required to procure an item using LCC.

During personal interviews with two PCO's at the NRCC, Detachment, the researcher found that these individuals were well versed in LCC basics and were confident of their abilities to procure suitable non-major systems using the LCC methodology. [Refs. 33 and 34] Thus, if the use of LCC should prove beneficial at the NRCC, Detachment, then it has a cadre of PCO's able to play the role of key person in this process.

2. Customer Participation

The participation of the customer is absolutely essential if the item is to be successfully purchased using LCC. The customer must understand the long range benefits of LCC. The customer should realize that systems with a lower total Life

Cycle Cost tend to have higher initial purchase prices; thus, the customer must be willing to provide the extra procurement dollars in order to realize the savings resulting from reduced operations cost. Moreover, the customer should be very precise in its requirements. The customer needs to clearly understand what the system is intended to do and how it will function. Only by understanding this kind of information can the customer provide the data necessary for the PCO to purchase the system using LCC. Because of these reasons, procurements using LCC will be difficult, if not impossible, without the full commitment of the customers throughout the process.

3. The Request For Proposal

The Request For Proposal (RFP) must carefully state four points to the potential contractors. First, the RFP should designate what costs are to be included as Life Cycle Costs; Chapter II can serve as a good basis to outline those costs. Second, the RFP must require the contractors to estimate LCC and include those projections in their proposals. Of course, the Life Cycle Costs are to be quoted as a present value. Third, the RFP should require supporting documentation, such as Mean-Time-Between-Failure tests or projected energy consumption calculations, be submitted to allow the contracting officer and engineering specialists to analyze and audit the proposed LCC. Finally, the RFP must clearly state that the contract will be awarded to the contractor submitting the lowest total LCC package. For instance, the RFP could have a statement like, "Contract award will be made to the responsive and responsible offeror submitting the proposal with the lowest total Life Cycle Cost.

Award will not be made regarding only initial purchase price." By using these four points as a starting point, the PCO can craft an RFP to meet the specific needs of the particular LCC procurement.

4. The Contractors

The contractors must be made aware that the Government will purchase the non-major system using LCC vice initial purchase price as the determining factor in who receives the contract. A second issue is whether the contractors would be willing to conduct the necessary LCC analysis. An answer to this issue came about as a secondary result of the author's research into performance levels. Surprisingly, all eight contractors called by the author to discuss their particular system's performance levels displayed keen interest in the LCC concept. [Refs. 35-42] Without exception, each of the contractors' representatives expressed his frustration over the Government's tendency to focus on the initial purchase price of an item when selecting the winning contractor. Not surprisingly, each representative stated that his system was the best on the market and tended to outlast his competitors' systems by wide margins. Overlooking this natural tendency to show pride in one's product, the author gathered that each of these eight contractors would be eager to submit their proposals based on LCC. Of course, this finding is a by product of other research and did not encompass a very large sample; but, in the author's opinion, this is a promising sign of the contractors' willingness to submit proposals using Life Cycle Costing.

E. SUMMARY

Chapter IV presented the Graham LCC Decision Model, its objectives and characteristics. This was followed by a discussion of the alterations necessary to adapt the Decision Model for selecting non-major systems that are LCC candidates purchased by the NRCC, Detachment. Finally, an explanation of the four basic points for procuring non-major systems using LCC was provided. Chapter V will apply the Modified Graham LCC Decision Model to the contracts awarded by the NRCC, Detachment from 1 January 1990 to 16 January 1992 to determine which of those contract awards were for valid LCC candidates.

V. APPLICATION OF THE MODIFIED LCC DECISION MODEL

A. INTRODUCTION

Three key points are discussed in Chapter V. First, prior to applying the Modified Graham LCC Decision Model for Non-Major Systems, the method used by the researcher to select the candidates for use in the Model is described. Second, the Modified Decision Model is applied to the candidates selected. The purpose of the application of the Modified Decision Model is to determine which contracts awarded by the NRCC, Detachment from 1 January 1990 to 16 January 1992 were suitable for the use of the Life Cycle Costing concept. Finally, the researcher will present an analysis of the results of the application of the Decision Model and telephone discussions with the four largest customers of the NRCC, Detachment. The primary goal of this analysis is to determine whether the use of LCC is appropriate at the NRCC, Detachment.

B. SELECTION OF POTENTIAL CANDIDATES

The process used by the researcher to select potential candidates for use in the Modified Decision Model is outlined in this section. The process consisted of three distinct steps; each step is described in detail below.

1. Step One

The first step was to request a computer listing of all contracts awarded by the NRCC, Detachment from 1 January 1990 to 16 January 1992 from the

Detachment's ADP personnel. Mr. J.D. Upshaw, Computer Systems Analyst, generated this report for the researcher on 16 January 1992. The computer report is listed as Reference 43 in the List of References. This report contains the following data elements:

-- Schedule

-- Document Number

-- Contractor

-- Description

-- Federal Supply Code (FSC)

-- Date Executed

A total of 1,495 contract awards for this time period were listed in the computer report. Both the researcher and the OIC of the NRCC, Detachment felt that this large set of contracts should be representative of the types and mix of contracts awarded by the Detachment. [Ref. 31] Furthermore, many contracts awarded prior to 1 January 1990 were closed out and the contract files have been transferred to the Federal Records Center. [Ref. 31] Consequently, since many older contract files were no longer available for review at the NRCC, Detachment, a two year period proved to be the longest available from which a practical sample could be derived.

2. Step Two

The second step was to classify the contract awards listed in Reference 43 into four categories. These categories are: service contracts, ADP related contracts (for both software and hardware), supply contracts and possible LCC candidates. The researcher used the description and the contractor listed in Reference 43 as the key data elements in classifying the 1,495 contract awards. The results of classifying the contracts listed in Reference 43 are displayed in Table 3.

TABLE 3

BREAKDOWN OF CONTRACT AWARDS LISTED IN REFERENCE 43

Category	Number of Contracts	Percentage of Total
Service Contracts	661	44.2%
All ADP Related Contracts	4[illegible]	31.2%
Supply Contracts	328	21.9%
Possible LCC Candidates	40	2.7%
Totals	**1,495**	**100.0%**

Several points should be made concerning the classification process. The use of the data elements "description" and "contractor" to classify the contracts into one of the four categories listed above is accurate and is a reasonable approach considering the number of contracts to classify. However, the researcher must point out that this process is not without some potential for error. The probability of a correct classification depends on the accuracy of the description assigned by the contracting specialist when inputing the data into the database and the ability of the researcher to interpret that description. Thus, it is conceivable that several potential

LCC candidates were misclassified. However, the descriptions were, for the vast majority of the items, very clear and simple to classify. A second point is that since LCC is a consideration in the contracting process for all ADP equipment and software, all ADP acquisitions have been excluded from study in this thesis. A third point is, for the purposes of this classification process, the researcher defined a supply contract as one for items such as spare parts, consumable items, tools or minor pieces of equipment. Common examples of the types of purchases the researcher classified as supply contracts are test sets, lumber, paper, rudder seals, boiler feed water, bearings, pallets and building supplies. The final point concerning the classification process is to describe how the researcher selected possible LCC candidates. The researcher defined a possible LCC candidate as any contract awarded for a system or a major piece of equipment; examples of these included such items as generator, metal shredder, optical tracking system, milling machine, pump, boiler and fire detection system. Basically, the researcher applied the four criteria of a valid LCC candidate named by Brown and Yanuck listed in Chapter II. [Ref. 1:p. 4] These criteria are energy intensiveness, long life expectancy, importance of efficiency of operation and degree of investment cost.

Through the use of the classification process discussed above, the researcher selected 40 contracts as possible LCC candidates.

3. Step Three

The third and final step in the selection process was to review the contract folders for each of the 40 possible LCC candidates. The purpose of this review was to gather the information necessary for the application of the Modified Decision Model. Such information required included: the contractor's address and telephone number, the customer's address and telephone number, a more specific description of the system purchased, quantity ordered, dollar value of the purchase, urgency of need and availability of competition.

Of the 40 contracts selected for the classification process discussed above, nine contracts were closed out and the contract files transferred to the Federal Records Center; thus, the number of potential candidates was reduced to a total of 31. A description of these 31 contracts is provided in Appendix C.

C. APPLICATION OF THE MODIFIED DECISION MODEL

The Modified Graham LCC Decision Model described in Chapter IV will now be applied to the 31 potential candidates as determined by the classification process outlined above. The researcher will apply the Modified Decision Model in much the same manner as a contracting officer would in an actual procurement situation. As a contracting officer would do in the actual contracting environment, the purpose of applying the Modified Decision Model is to determine which of the 31 candidates should be purchased using LCC techniques. The candidates will be tested using the nine decision characteristics in the same order as they appear in the Modified Decision Model. Each candidate that fails to meet the criteria specified for a particular decision is immediately rejected, as would be the case in actual practice. All contracts that fail to meet the decision's requirements are listed at that decision with a brief explanation of why it was rejected. Perhaps the reader will find it helpful to refer to Figure 7 in Chapter IV occasionally to see where in the Modified Decision Model particular candidates are eliminated. Moreover, Appendix C may be helpful in determining why a candidate was rejected. Appendix C lists all 31 candidates in contract number sequence; the following information is provided for each candidate in Appendix C: contract number, award date, contractor, customer, nomenclature, quantity ordered, total price and comments as necessary.

The Modified Graham LCC Decision Model for Non-Major Systems is applied below. Each decision is listed and is accompanied by a decision number to assist the reader in determining where the decision is in the Model.

1. Urgency of Requirement (Decision Number 1)

Six of the 31 potential LCC candidates are urgent requirements. Therefore, these six are eliminated from further consideration. Each of these is listed below in contract number sequence.

a. Contract Number: N00123-90-C-0012

Nomenclature: Diesel Generator

Brief Explanation: The Diesel generators were required for delivery within 15 days of contract award in order to maintain the scheduled reactivation of the USS Missouri (BB-63).

b. Contract Number: N00123-90-C-0838

Nomenclature: Fan

Brief Explanation: The fans were needed to prevent a work stoppage costing $30,000 per day.

c. Contract Number: N00123-91-C-0052

Nomenclature: Butterfly Valve

Brief Explanation: The butterfly valves were a urgent requirement for work by the Long Beach Naval Shipyard (LBNS) on the USS Belleau Wood (LHA-3).

d. Contract Number: N00123-91-C-0228

Nomenclature: Pump

Brief Explanation: The pumps were needed within six weeks to remove toxic wastes from the LBNS's drydock.

e. Contract Number: N00123-92-C-0079

Nomenclature: Baking and Roasting Ovens

Brief Explanation: The ovens were required by the LBNS for delivery within eight weeks to complete work on the USS Peleliu (LHA-5).

f. Contract Number: N00123-92-C-0110

Nomenclature: Butterfly Valve

Brief Explanation: The butterfly valves were urgently required by the LBNS to complete work on the fuel system of the USS Peleliu (LHA-5).

2. Availability on the Open Market (Decision Number 2)

Ten of the 25 remaining LCC candidates are available only from a sole source. Therefore, these ten items have been rejected from further consideration. Each of these ten items is listed below in contract number sequence.

a. Contract Number: N00123-90-C-0108

Nomenclature: Gypsy Winch

Brief Explanation: The assemblies specified are proprietary to Superior-Lidgewood-Mundy Corp. The information as spelled out in the plans contains no engineering specifications for competition. The cost of providing plans which contain engineering data would be too great.

b. Contract Number: N00123-90-C-0416

Nomenclature: Water Circulating Pump

Brief Explanation: The M.T. Davidson Co. controls the proprietary rights to these pumps which are required to complete a pending Ship Alteration on four ships. Moreover, M.T. Davidson is the only source to express interest in this item.

c. Contract Number: N00123-90-C-0543

Nomenclature: Thermal Vacuum Space Simulator System

Brief Explanation: Tenney Engineering is the sole manufacturer of the equipment required to meet the Naval Postgraduate School's needs.

d. Contract Number: N00123-90-C-0622

Nomenclature: Gypsy Winch

Brief Explanation: See contract number N00123-90-C-0622.

e. Contract Number: N00123-90-C-0737

Nomenclature: Water Circulating Pump

Brief Explanation: See contract number N00123-90-C-0416.

f. Contract Number: N00123-91-C-0317

Nomenclature: Spacecraft Attitude Control System Simulator

Brief Explanation: Communication Satellite is the only known contractor that already has the specialized knowledge necessary to produce this item. The Government estimated that the development cost for a second contractor to produce this item would be no less than $1,000,000.

g. Contract Number: N00123-91-C-0483

Nomenclature: Power Amplifier

Brief Explanation: Loral Terracom is the original equipment manufacturer and possesses proprietary data rights to the system.

h. Contract Number: N00123-91-C-0725

Nomenclature: Auxiliary Boiler

Brief Explanation: While the boiler does have a National Stock Number (NSN), it is a made-to-order, long lead time item available only from Chromalox and is not stocked in the Navy Supply System. The item manager approved the local procurement.

i. Contract Number: N00123-92-C-0060

Nomenclature: Benthic Acoustic Stress Sensor System

Brief Explanation: Extensive market research revealed that only Oceanographic Instrument Systems holds the patent rights to this type of system.

j. Contract Number: N00123-92-C-0087

Nomenclature: Torpedo Adapter Assembiy

Brief Explanation: This is a unique item for the USS Oldendorf (DD-972). Previously, the LBNS had fabricated a similar, smaller assembly in 1989. Crane Defense Systems proved to be the only commercial source for this assembly.

3. Total Procurement Cost (Decision Number 3)

Seven of the remaining 15 candidates have a total procurement cost less than the threshold of $100,000; consequently, these seven items have been excluded from consideration. Each of these seven items is listed below in contract number sequence.

a. Contract Number: N00123-90-C-0273

Nomenclature: Bar Coding Equipment

Brief Explanation: The total procurement cost for this equipment was $76,325.

b. Contract Number: N00123-90-C-0344

Nomenclature: Milling Machine

Brief Explanation: The milling machine was acquired for $34,900.

c. Contract Number: N00123-91-C-0234

Nomenclature: Bridge Crane Assembly

Brief Explanation: This assembly cost $44,598.

d. Contract Number: N00123-91-C-0594

Nomenclature: Material Handling System

Brief Explanation: The total procurement cost for this system was $50,064.

e. Contract Number: N00123-92-C-0134

Nomenclature: Oscilloscope

Brief Explanation: The price for this piece of equipment was $27,505.59.

f. Contract Number: N00123-92-C-0149

Nomenclature: Laser

Brief Explanation: This item cost the Government $32,849.96.

g. Contract Number: N00123-92-C-0160

Nomenclature: Damage Control Console

Brief Explanation: The total procurement cost for this item was $40,213.

4. Expected Service Life (Decision Number 4)

All eight of the remaining candidates have an expected service life of at least five years.

5. Maturity (Decision Number 5)

Two of the remaining eight candidates fail to meet the maturity of design characteristic. These two items are listed below in contract number sequence.

a. Contract Number: N00123-91-C-0468

Nomenclature: Radar Receiver

Brief Explanation: The researcher called and spoke with Leonard Johnson, ele 'rical engineer, Radian Technology to gather information on the radar receiver. [Ref. 36] Johnson pointed out that this receiver was a developmental item for the Pacific Missile Test Center, Point Mugu, CA. [Ref. 36] Consequently, the item is not of mature design and no reliability data have been recorded or projected for the system.

b. Contract Number: N00123-91-C-0724

Nomenclature: Medium Range Navigation System

Brief Explanation: The researcher called and spoke with James Lassiter, owner of Maxiran Corp. to collect information on the navigation system. [Ref. 38] Lassiter stated that the system was developmental and no failure rates have been determined. [Ref. 38]

6. Efficiency of Operation (Decision Number 6)

Efficiency of operation is an important consideration for each of the six remaining candidates. As discussed in Chapter IV, the application of the four system attributes related to the efficiency of operation of a system, energy efficiency, maintainability, reliability and simplified operation, can significantly lower each candidate's total LCC.

7. Technical Data (Decision Number 7)

Adequate technical data are available for each of the six remaining candidates. Thus, if all six candidates meet the remaining two criteria, then the contracting officer will have sufficient technical data to construct an RFP which contains the technical information necessary for the potential contractors to submit proposals based on LCC.

8. Performance Measures (Decision Number 8)

One of the six surviving LCC candidates does not have an adequate performance measure. This item is listed below.

a. Contract Number: N00123-90-C-0040

Nomenclature: Temperature Calibration System

Brief Explanation: The researcher spoke with Dr. Sostmann, who holds a Ph. D. in physics and was the designer of the system. [Ref. 40] Dr. Sostmann stated that performance measures in the classical use of the term are undefined for this system. [Ref. 40] For instance, he pointed out that this system essentially has no limit to the number of calibrations possible before system failure. [Ref. 40] The system, according to Dr. Sostmann, consists of no mechanical devices; thus, there is no wear and the only friction or metal fatigue that occurs is when the furnaces are heated and cooled. Dr. Sostmann contends that the most common form of system failure occurs when a technician drops or breaks a critical component, such as a recorder or an adapter. Since no MTBF information has been gathered and no calculations have been performed to determine the average number of temperature calibrations the system can perform before failure, the researcher has determined that performance measures, in the context of this thesis, have no meaning for this system. Consequently, this temperature calibration system has been rejected from consideration.

9. **Performance Levels (Decision Number 9)**

All five of the remaining candidates have excellent data on their performance levels available.

10. **Procure Using LCC Techniques (Decision Number 10)**

The five candidates that successfully met all of the requirements of the Modified Graham LCC Decision Model for Non-Major Systems are listed below.

a. Contract Number: N00123-90-C-0044

Contractor: SSI Shredding Systems

Customer: Naval Weapons Station
Seal Beach, CA

Nomenclature: Metal Shredder

Quantity: 1 each

Total Price: $105,000

b. Contract Number: N00123-90-C-0126

Contractor: KINTEC

Customer: Naval Weapons Station
Seal Beach, CA

Nomenclature: Lightweight Portable Optical
Tracking System

Quantity: 1 each

Total Price: $446,378

c. Contract Number: N00123-90-C-0344

Contractor: Hansome Energy Systems, Inc.

Nomenclature: Electric Motor

	Quantity: Total Price:	4 each $202,300
d.	Contract Number:	N00123-91-C-0402
	Contractor:	Harnischfeger Corp.
	Customer:	Long Beach Naval Shipyard Long Beach, CA
	Nomenclature:	Hoist Assembly for Weapons Elevator
	Quantity:	1 assembly
	Total Price:	$422,000
e.	Contract Number:	N00123-92-C-0089
	Contractor:	DYNALEC Corp.
	Customer:	Long Beach Naval Shipyard Long Beach, CA
	Nomenclature:	Shipboard Fire Detection System
	Quantity:	1 each
	Total Price:	$199,608.46

D. ANALYSIS OF RESULTS

In this section, an analysis of the results of applying the Modified Decision Model is presented. Three areas will be discussed. First, the common reasons for rejecting an item as a Life Cycle Costing candidate from the Modified Decision Model are analyzed. Second, the ease of use of the Modified Decision Model is evaluated. Finally, and most importantly, an analysis is presented on whether the use of LCC for purchasing non-major systems at the NRCC, Detachment is beneficial.

1. Analysis of Reasons for Rejection from the Model

Table 4 lists a breakdown of the reasons candidates were eliminated from onsideration as a Life Cycle Costing candidate.

As can be gathered from Table 4, the single most common reason for elimination as a candidate is the lack of competition; notice that 38.5% of the 26 items excluded were rejected due to the lack of competition. This is particularly surprising given the current emphasis on competition in Government contracting. Also, six of the ten candidates rejected due to lack of competition were items purchased from contractors with proprietary data rights. The second most common reason for rejection was failure to meet the minimum total procurement cost of$100,000. Overall, 26.9% of the rejected items were discarded for this reason. The rejection rate for the dollar value threshold appears to be reasonable. This observation is based on two points. First, the NRCC, Detachment tends to purchase a large number of non-major systems priced in the tens of thousands of dollars. [Ref. 43] Second, many of the purchases made by the Detachment are for very limited quantities; typically, only one or two units of a particular item are purchased. [Ref. 43] Consequently, a large number of purchases made by the Detachment will fall between $25,000 and $100,000. The final major reason for elimination from consideration is the urgency of requirement; a total of 23.1% of the 26 items rejected were excluded for this reason. Furthermore, all six of the candidates eliminated for

TABLE 4

BREAKDOWN OF REASONS FOR ELIMINATION FROM THE MODIFIED DECISION MODEL

Decision Characteristic	Number of Items Rejected	Percentage of Total
1. Urgency of Requirement	6	23.1%
2. Availability of Competition	10	38.5%
3. Total Procurement Cost	7	26.9%
4. Expected Service Life	0	0.0%
5. Maturity	2	7.7%
6. Efficiency of Operation	0	0.0%
7. Technical Data	0	0.0%
8. Performance Measures	1	3.8%
9. Performance Levels	0	0.0%
Total	**26**	**100.0%**

this reason were purchases for the Long Beach Naval Shipyard. This simply reflects the scheduling difficulties and uncertainties involved in repairing and overhauling naval vessels. [Ref. 31] Altogether these three characteristics, availability of competition, total procurement cost and urgency of requirement, accounted for 88.5% or 23 of the 26 items rejected from the Modified Decision Model.

The least common reasons for rejection were maturity and performance measures. As displayed in Table 4, 7.7% of the excluded items were discarded for lack of maturity. This relatively low percentage parallels the types of non-major systems purchased by the NRCC, Detachment. Only very rarely will the Detachment purchase a developmental item. [Ref. 31] Only 3.8% of the 26 rejected items do not have adequately defined performance measures. In the researcher's opinion, the single item that failed to have adequate performance measures was a unique item; the overwhelming majority of the non-major systems purchased by the Detachment should have adequately defined performance measures.

Finally, four of the nine decision characteristics, expected service life, efficiency of operation, availability of technical data and performance levels did not have any candidates fail to meet their respective criteria.

2. Evaluation of the Ease of Use of the Model

A key consideration in developing the Modified Decision Model is the ease of use or simplicity of the Model. In developing the original Model, Graham also sought to have a model that was as simple as possible to use. [Ref. 5:p. 42] A model that is difficult and time consuming to use will face many obstacles in being implemented. However, a model that is relatively simple to use and does not require a large investment of time from the user will face much less resistance. Consequently, the researcher has attempted to evaluate the ease of use of the Modified Decision Model.

The researcher has selected two measures to evaluate the ease of use of the Decision Model. One measure is to simply estimate the average time required to process a candidate through the Modified Decision Model. The second is to determine how quickly the candidates which are not suitable for LCC are eliminated from consideration. This measure indicates how long the user analyzes an unsuitable candidate before it is rejected. Also, this measures the effectiveness of the order of the decision characteristics in the Modified Decision Model.

First, the average time required to process the candidates is discussed. The time needed for the researcher to process all 31 candidates through the Model was approximately 120 minutes. Thus, the average time per candidate is roughly four minutes. This average time excludes the time required to gather all the information necessary to process a candidate through the Model. The researcher estimates that the time required for the contracting officer to amass the necessary data could average up to two hours for each candidate. This estimate is based on the length of time required by the researcher to collect all the information needed to process the candidates. Typically, the researcher was able to obtain the bulk of the data from the contract folder in a matter of minutes, which the contracting officer would also be able to do in actual practice. However, many items would require several telephone conversations with the customer and the potential contractors to obtain such information as expected service life, the importance of efficiency of operation, performance measures, performance levels, the availability of additional funding from the customer, and so forth. Consequently, the researcher estimates that the average time to collect the necessary information and apply the Model would range from two to three hours for each candidate. However, this is just an estimate based on the researcher's experience. The actual average could be somewhat different in practice. In the researcher's opinion, a two to three hour average time to process an item through the Model is a reasonable length of time given the small number of candidates at the NRCC, Detachment. Or, in other terms, the researcher estimates that, using three hours as the average time to collect the required data and then process the candidate through the Model, the 31 candidates would require approximately 93 man-hours to process. Spread over a two year period of time, which matches the period of time the candidates were selected from, this amount of effort is quite small.

The second measurement is to determine how quickly or at what rate the unsuitable candidates are eliminated from consideration in the Modified Decision Model. As noted earlier, 88.5% of the unsuitable candidates were eliminated by the first three decision characteristics. The bulk of the unsuitable candidates were rejected very early in the Model. Furthermore, these three decision characteristics are all relatively simple to determine. Thus, the order of consideration of the decision characteristics in the Modified Decision Model is quite effective. The ordering of the decision characteristics appears to have met the objective of rapidly eliminating those candidates that can be rejected with the least amount of research and effort.

Using the two evaluation criteria outlined above, the researcher's analysis has determined that the Modified Decision Model is relatively simple to use and should not require an excessive amount of time to process individual candidates. Furthermore, the actual use of the Modified Decision Model has demonstrated that it is structured to quickly and easily eliminate unsuitable candidates.

3. Analysis of the Usefulness of the LCC Concept at the NRCC, Detachment

The key issue in this thesis is to determine whether the use of LCC techniques for purchasing non-major systems is beneficial at the NRCC, Detachment. As pointed out earlier, the Detachment does not currently consider Life Cycle Costs when purchasing non-major systems. [Ref. 31] Thus, the central issue is to determine if the benefits of implementing the use of LCC techniques for purchasing non-major systems outweigh the costs.

The researcher has selected three criteria with which to analyze the usefulness of LCC at the NRCC, Detachment. First, the number of LCC candidates selected through applying the Modified Decision Model is the single most important indication of whether Life Cycle Costing should be implemented at the NRCC, Detachment. Obviously, if very few viable candidates are available, then the use of LCC is not warranted. However, if a multitude of candidates are present, then the use of LCC can be easily be supported. Second, the level of experience with LCC already possessed by the customers, contracting officers and contractors is also a key indication as to the usefulness of LCC at the Detachment. The level of experience determines the degree of training, education and learning required for these three groups to implement the LCC technique. Of course, if all three groups are familiar with LCC methods, then the implementation at the NRCC, Detachment would be relatively simple. In contrast, if a large amount of training is required, then the implementation would be much more difficult. Third, the last consideration is the willingness and ability of the customers of the NRCC, Detachment to participate in the LCC process. As discussed in Chapter IV, the customer is absolutely essential for the effective use of LCC. Each of these three criteria is discussed in detail below.

a. Number of LCC Candidates

The first criterion is the number of LCC candidates selected through applying the Modified Decision Model. As noted above, the researcher considers this criterion to be the single most important indicator as to the usefulness of Life Cycle Costing for purchasing non-major systems at the NRCC, Detachment. Of the 1,495 contracts awarded from 1 January 1990 to 16 January 1992, the researcher has determined that only five were contracts for valid LCC candidates. Thus, in terms of the total number of contracts awarded, the percentage of valid LCC candidates over this period of time is only 0.33%. In terms of the average dollar value of contracts awarded in a given year by the NRCC, Detachment, the combined dollar value of the five valid LCC candidates is 0.31% of the average yearly total. Therefore, based on the results listed above, the researcher has determined that the number of potential LCC candidates purchased by the NRCC, Detachment is simply not large enough to warrant the use of Life Cycle Costing.

b. Level of Experience

The second criterion is the level of experience with Life Cycle Costing already possessed by the contracting officers, customers and contractors. Of the three criteria, this is the most difficult to quantify; however, the researcher has formed a reasonable view of the experience levels of these three groups during telephone conversations and personal interviews. During personal interviews at the NRCC, Detachment, the researcher found that virtually all of the PCO's were well versed in the theoretical aspects of LCC. [Refs. 31, 33 and 34] Also, all were confident of their abilities to procure items using Life Cycle Costing. However, the researcher also determined that the PCO's, with the exception of those purchasing ADP items, had no actual experience in purchasing an item using LCC techniques. [Refs. 31, 33 and 34] Moreover, the researcher's conversations with the four largest customers revealed that, for the most part, they have no experience with LCC. [Refs. 44-48] In one case, the researcher had to explain the basics of Life Cycle Costing to a contracting specialist in order to obtain answers to several questions. [Ref. 46] Consequently, the customers would require a significant amount of training and education to be able to provide the information and assistance needed for contracting officers to purchase their requirements using LCC. Surprisingly, the eight contractors the researcher spoke with appeared to have the greatest amount of practical experience with LCC. [Refs. 35-42] As noted in Chapter IV, all eight of the contractors called by the researcher displayed keen interest in the LCC concept. [Refs. 35-42] Furthermore, each of the contractors' representatives was very comfortable in discussing such system attributes related to LCC as expected service life, Mean Time Between Failure, Mean Time To Repair, etc.

In the researcher's opinion, the two Government groups, the contracting officers and the customers, would require a substantial amount of training and education to be able to confidently purchase items using LCC. Given the very small number of valid LCC candidates, this effort would not be cost effective.

c. Customer Willingness

The final consideration is the willingness and ability of customers of the Detachment to participate in the LCC process. As pointed out earlier, the customer is an essential component of the LCC process. Without the customer's full participation, the LCC effort cannot succeed. As discussed in Chapter II, LCC almost always requires a higher initial investment or purchase price in order to design and produce systems with lower operations and maintenance costs. Thus, the key area of concern for the researcher was to determine the ability and willingness of the four major customers to fund the higher initial procurement cost of purchasing systems with a lower Life Cycle Cost. In order to determine this, the researcher called all four of the major customers of the NRCC, Detachment. In these telephone conversations, the researcher found that all four of the customers were deeply concerned about budget constraints and were not disposed to spend any more money than was required to meet their immediate, minimum needs. [Refs. 44-48] Typical comments from the customers are provided below. One contracting specialist stated, "I don't believe they [the customers] would pay the extra cost for Life Cycle Costing in FY's 1992 and 1993. Their budgets are too tight." [Ref. 46] A head project officer commented, "We have to try to meet immediate needs within our budget. The budget does not look beyond the immediate plan." [Ref. 47] An electrical engineer remarked, "The minimum Government requirements are the driving factor." [Ref. 44] An ordnance production superintendent stated, "I do not feel comfortable with these [Life Cycle Costing] estimates. Anyway, we buy to our minimum requirements at the lowest cost." [Ref. 48] Finally, a contracts branch head commented, "We don't have a chance to look at that [Life Cycle Costing]. Most of the items are specified to us anyway." [Ref. 45] These statements clearly indicate that the Detachment's customers face severe budget constraints; and, consequently, would not be willing to spend more than is absolutely required to meet immediate needs. Therefore, this final indicator also does not support the use of LCC at the NRCC, Detachment.

To recapitulate, all three criteria selected by the researcher to analyze the usefulness of LCC at the NRCC, Detachment indicate that Life Cycle Costing should not be implemented.

E. SUMMARY

Three key points were presented in Chapter V. First, the method used by the researcher to select the candidates for use in the Modified Graham LCC Decision Model for Non-Major Systems was described. Second, the Modified Decision Model was applied to the 31 candidates selected. Of the 31 candidates, only five were determined to be viable LCC candidates. Lastly, the researcher presented an analysis of the results of the application of the Modified Decision Model. The significant results of this analysis were threefold. One finding was that three decision characteristics, availability of competition, total procurement cost and urgency of requirement, accounted for 88.5% or 23 of the 26 items rejected from the Modified Decision Model. A second finding was that the Decision Model is relatively simple to use and should not require an excessive amount of time to process individual candidates. The third finding was that primarily because of the very few valid LCC candidates purchased by the Detachment and the unwillingness of the customers to participate, the usefulness of the LCC concept at the NRCC, Detachment is severely limited.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

Chapter VI is primarily a summary and a recapitulation of the entire thesis. In this chapter, the researcher presents thesis conclusions and recommendations. It also provides answers to the principal and subsidiary research questions posed in Chapter I. Finally, the researcher lists several areas for future research and study.

B. CONCLUSIONS

Conclusion 1. The usefulness of the Life Cycle Costing concept for purchasing non-major systems at the Naval Regional Contracting Center, Detachment, Long Beach is severely limited.

This conclusion is based on the three criteria the researcher selected to analyze the usefulness of LCC for procuring non-major systems at the NRCC, Detachment discussed in Chapter V. First, the researcher determined that the number of potential LCC candidates purchased by the NRCC, Detachment is simply not large enough to warrant the use of Life Cycle Costing. Of the 1,495 contracts awarded from 1 January 1990 to 16 January 1992, the researcher determined, through the use of the Modified Graham LCC Decision Model for Non-Major Systems, that only five purchases were for valid LCC candidates. Thus, in terms of the total number of contracts awarded, the percentage of valid LCC candidates over this period of time is only 0.33%. Second, the researcher determined that the two Government groups involved in the contracting process, the contracting officers and the customers, would require a substantial amount of training and education to be able to confidently purchase non-major systems using Life Cycle Costing. Given the very small number of valid LCC candidates, this effort would not be cost effective. Finally, the researcher found that the major customers of the NRCC, Detachment face severe budget constraints; and, consequently, these commands would not be willing to spend more than is absolutely required to meet immediate needs. In other terms, the major customers of the NRCC, Detachment are unwilling to pay a higher initial acquisition cost for a non-major system in order to realize reduced operations, support or maintenance costs in the future.

Conclusion 2. The Graham Life Cycle Costing Decision Model for Spare Parts can be successfully modified to evaluate whether a particular non-major system should be procured using LCC techniques.

Building upon the excellent foundation constructed by Graham, the researcher was able to develop the Modified Graham Life Cycle Costing Decision Model for Non-Major Systems. The primary goal in modifying the original Decision Model was to make it suitable for evaluating which non-major systems purchased by the NRCC, Detachment were viable LCC candidates; as demonstrated in Chapter V, the Modified Decision Model performed this task remarkably well. A summary of the alterations made to the original Graham LCC Decision Model is found in Table 2 located in Chapter IV. The four major changes made by the researcher were: First, the minimum total procurement cost for the candidate was raised from $10,000 to $100,000. Second, a test to determine if the expected service life of the non-major system is greater than five years was added to the Decision Model. Third, an examination to determine if the efficiency of operation for a given non-major system is an important consideration was added to the Model. Lastly, several decision characteristics related only to spare parts, such as shelf life, were eliminated from the original Decision Model. Furthermore, a detailed discussion of the specific changes made to the original Graham LCC Decision Model is presented in Chapter IV.

Conclusion 3. The Modified Graham LCC Decision Model for Non-Major Systems is relatively simple to use and does not require an excessive amount of the user's time to process potential candidates through it.

As discussed in Chapter V, a key consideration in developing the Modified Decision Model was the ease of use or simplicity of the Model. The researcher selected two measures to evaluate the ease of use of the Modified Decision Model. The first measure is the average time required to process the potential candidate through the Model. The researcher found that the average time to collect the necessary information and apply the Modified Decision Model would range from two to three hours for each candidate. The researcher also determined that a two to three hour average time to process an item through the Modified Decision Model is a reasonable length of time given the small number of candidates at the NRCC, Detachment. Or in other terms, using three hours as the average time to collect the required data and then process the candidate through the Model, the 31 potential candidates would require approximately 93 man-hours to process. Over a two year period of time, which matches the period of time the candidates were selected from, this level of effort is quite small. The second measurement is to determine how quickly or at what rate the unsuitable candidates were eliminated from consideration in the Modified Decision Model. As noted in Table 4 located in Chapter V, 88.5% of the unsuitable candidates were eliminated by the first three decision characteristics of the Modified Decision Model. Furthermore, these three decision characteristics are all relatively simple to determine. Thus, the order of consideration of the decision characteristics appears to have met the objective of rapidly eliminating those candidates which can be rejected with the least amount of research and effort. As can be seen from these two measurements and its actual use, the Modified Decision Model is structured to quickly and easily eliminate unsuitable candidates.

Conclusion 4. The Procuring Contracting Officer (PCO) is the key person in the Life Cycle Costing process.

As pointed out in Chapter IV, the PCO should be responsible for coordinating the effort of utilizing Life Cycle Costing. No other individual is in the unique position to be able to communicate with the potential contractors, the engineering specialists and the customer. Thus, the PCO, assisted by subordinate contracting specialists, acts as the "clearinghouse" for all the information necessary to procure an item using the Life Cycle Costing technique.

Conclusion 5. The implementation and coordination of a Life Cycle Costing effort would be difficult to achieve at the NRCC, Detachment.

As noted throughout the thesis, the NRCC, Detachment does not currently utilize LCC techniques for purchases other than for Automatic Data Processing related equipment and software. Thus, the coordination and use of Life Cycle Costing would face at least three major institutional obstacles. First, no standard procedures exist on how to utilize LCC for non-major systems. A consequence of this is that using LCC for purchasing a particular non-major system must be accomplished on an ad hoc basis. Second, no clear responsibilities are outlined as to which individuals are required to perform which functions; thus, all the actions required to purchase an item using LCC may not be taken simply because the individuals involved are not aware that they are responsible for them. Finally, and most importantly, given the current circumstances, no immediate incentives exist for any of the three groups involved in the contracting process, the contracting officer, the customer and the contractor, to use the Life Cycle Costing technique. In fact, each group would face disincentives which must be overcome. For instance, the use of LCC would require a much greater commitment of time and effort from the contracting officer when compared to purchasing the same item using standard contracting techniques. The use of LCC would require a greater investment in both dollars for the item and in effort to develop and clarify precise requirements by the customer. The contractor, in order to produce an item with lower total LCC, typically must charge a higher purchase price for the item; thus, this places the contractor at a potential price disadvantage.

Conclusion 6. Contractors appear to be eager to submit future proposals using Life Cycle Costing techniques, if requested to do so by the Government in its solicitations.

This finding came about as a secondary result of the author's research into performance levels. Surprisingly, all eight contractors called by the researcher to discuss their particular system's performance levels displayed keen interest in the Life Cycle Costing concept. Without exception, each of the contractor representatives expressed frustration over the Government's tendency to focus on the initial purchase price when selecting a contractor. Not surprisingly, each representative stated that his system was the best on the market and tended to outlast his competitors' systems by wide margins. Discounting this natural tendency to display pride in one's product, the researcher noted that each of these eight contractors would be eager to submit future proposals based on LCC. As pointed out in Chapter IV, this finding is a by product of other research and did not encompass a very large sample; but it is a clear indication of these contractors' willingness to submit proposals using Life Cycle Costing.

Conclusion 7. The use of Life Cycle Costing is an effective means of minimizing the total cost of ownership of a particular system.

Typically, a reduction in total ownership cost is achieved only after careful analysis of design trade-offs of alternative system configurations which fulfill the same system requirements. Since such factors as performance, quality, maintenance, energy consumption and initial cost are all interdependent, the LCC concept seeks to find that optimal balance of lowest cost between them. [Ref. 14:p. 9] A classical LCC analysis would compare the future benefits of reducing operations costs to the immediate cost of producing the system capable of meeting that future requirement. As Marks and Massey point out,

> The major characteristic of these kinds of investment decisions [the use of LCC] is that they are made with the expectation of some sort of tangible payoff--usually in the form of downstream operations and support cost savings, hence a reduction in overall Life Cycle Cost. [Ref. 21:p. 13]

Consequently, decision makers, in order to achieve the objective of the Life Cycle Costing concept, must choose to accept the required current cost in order to gain the future benefits of a low LCC system.

Conclusion 8. A Life Cycle Costing analysis should only be conducted when the potential benefits outweigh the cost associated with the analysis.

Brown and Yanuck have identified four major attributes a system should possess before the LCC concept should be applied to it. [Ref. 1:p. 4] These factors are: First, LCC should be considered when the anticipated energy consumption of the item is expected to be large throughout its entire Life Cycle. Second, LCC is significant for systems with lengthy service lives. For items with long lives, costs other than initial acquisition cost become preponderant, while for items with short lives, the initial acquisition cost is more important. A third important system attribute for Life Cycle Costing purposes is efficiency of operation. The use of LCC is appropriate when the efficiency of operation of a system is an important consideration; a key consideration is to determine whether significant cost savings can be realized through reducing operations, maintenance, support or personnel costs. Finally, as a general rule, the greater the capital investment the more important the use of a Life Cycle Costing analysis becomes.

In addition to the four factors discussed above, Graham identifies two other factors that should be considered prior to conducting a Life Cycle Costing analysis. [Ref. 5:pp. 45-48] These are: First, the availability of competition provides potential contractors the incentive to meet and exceed minimum requirements at the lowest cost possible. Second, only mature technologies or designs have sufficient historical data available to pursue a LCC analysis.

Conclusion 9. The Life Cycle Costing concept has many potential benefits for the Government.

The five key benefits of the Life Cycle Costing concept are provided below.

-- The use of LCC is a means of reducing the total cost of ownership of an asset. [Ref. 2:p. 30] The costing data produced from the LCC analysis allows decision makers to select the most beneficial procurement strategy, determine the significant cost drivers of a system, make design trade-offs or make source selections. [Ref. 2:p. 30]

-- The use of LCC is a means of improving the reliability of a system. [Ref. 17:p. 6] The LCC methodology by its very nature considers the future benefits of producing a system that is more reliable. Consequently, beginning with the initial design of the system, design engineers are considering such factors as simplification, higher quality materials, rigorous testing and redundancy all as attempts to increase a system's reliability.

-- The use of LCC can improve a system's maintainability. [Ref. 17:p. 7] This benefit is very closely related to the reliability of a system. Ease of maintenance can be simply and cheaply designed into a system from the outset. The maintainability of a system can be increased by using simplification and standardization of design and equipment, increasing access to those components most likely to fail or providing the test equipment used to isolate faults.

-- The use of LCC forces decision makers to act and plan for the long-term vice the short-term. [Ref. 2:p. 11] In the context of LCC, long-term refers to a system's entire Life Cycle, while the short-term focuses entirely on initial cost. Inherent to the LCC concept is the idea that the immediate investment in a system that is more reliable, consumes less energy, requires less maintenance or will simply last longer will be richly repaid over the entire Life Cycle of the system.

-- The LCC methodology forces the end-users to thoroughly identify their precise needs. [Ref. 14:p. 13] The end-user, assisted by LCC specialists, must determine such system characteristics as mission requirements, operational environment, maintenance concepts, design criteria, personnel support and logistics planning prior to initiating system development.

Consequently, the LCC technique requires the end-user to completely describe what is needed, how it will be used and how it will be supported.

C. RECOMMENDATIONS

Recommendation 1. Do not adopt the use of Life Cycle Costing techniques for the purchase of all non-major systems at the NRCC, Detachment.

As demonstrated in Chapter V, the NRCC, Detachment does not purchase a sufficient number of valid LCC candidates to warrant the implementation of the Life Cycle Costing concept for all non-major systems purchased. However, the researcher did discover five non-major systems that were valid LCC candidates; these five systems are listed in Chapter V. Because of these five viable candidates, the researcher does not recommend rejecting the use of LCC altogether; rather, the LCC concept could be applied to those very few candidates that have the potential for large savings in total ownership costs for the Government. The researcher should point out that the use of LCC on an infrequent basis would be exceedingly difficult. The specific reasoning for this observation was discussed in Conclusion 5.

Recommendation 2. Apply the Modified Graham LCC Decision Model for Non-Major Systems to other field contracting activities to determine whether those activities purchase a large number of Life Cycle Costing candidates.

Since the types, dollar value and mix of contract awards vary somewhat from one field contracting activity to another, field contracting activities other than the NRCC, Detachment may purchase large numbers of non-major systems that are suitable LCC candidates. Thus, although the use of LCC at the NRCC, Detachment is not warranted, its application at other field contracting activities could pay rich dividends.

Recommendation 3. Apply the Modified Graham LCC Decision Model for Non-Major Systems at an Inventory Control Point (ICP).

Since Inventory Control Points, such as the Navy Ships Parts Control Center and the Navy Aviation Supply Office, control and monitor the purchase of large quantities of potential LCC candidates, the use of Life Cycle Costing at an ICP could prove beneficial. The basis for this recommendation is found in Table 4 located in Chapter V. As seen in Table 4, exactly 50% of the candidates rejected from consideration at the NRCC, Detachment were eliminated because of either urgency of requirement or failure to meet the minimum procurement cost of $100,000. Possibly, an ICP would not face these two obstacles, which would dramatically increase the number of viable LCC candidates.

Recommendation 4. Educate contracting officers to recognize those systems that possess the characteristics necessary for the successful application of the Life Cycle Costing technique.

Educating contracting officers throughout the Government to recognize which system possess the potential for LCC analysis may have powerful results; as discussed earlier, these results are a reduction in ownership costs, increased reliability, improved maintainability or enhance requirements planning for the long-term by the customer. Furthermore, the training required to achieve this recommendation could be accomplished in a matter of hours; the education could possibly be integrated into a course already required for contracting officers to attend.

Recommendation 5. Encourage contractors to submit proposals for selected non-major systems using Life Cycle Costing.

When writing a Request For Proposal (RFP) for a non-major system that is a suitable LCC candidate, the contracting officer should have the flexibility and authority to include Life Cycle Costing as a consideration. Thus, the contractor who produces a system with low total ownership costs, but at a higher initial purchase price, is not placed at a competitive disadvantage. Also, this will encourage contractors to consider LCC for appropriate systems.

Recommendation 6. For selected purchases, elevate LCC considerations to the same status as an evaluation criterion as unit cost, schedule and performance.

This recommendation closely parallels Recommendation 5. If Life Cycle Costing considerations are placed in the RFP, then they should also be used when evaluating which contractor receives the contract award. Furthermore, the use of LCC as an evaluation criterion would clearly demonstrate its importance to potential contractors.

D. ANSWERS TO THE RESEARCH QUESTIONS

1. Answers to the Subsidiary Research Questions

What is Life Cycle Costing?

Life Cycle Costing is the process of using a set of models and techniques to develop a detailed cost estimate of the total lifetime cost of a system. [Ref. 14:p. 9] The Life Cycle Cost of a particular system includes such costs as research and development costs, investment cost, operations and support costs, and disposal cost.

Under what conditions should Life Cycle Costing be used?

The Life Cycle Costing technique should not be used for every purchase. A Life Cycle Costing analysis adds to the cost of a system. Consequently, LCC analysis should only be conducted when the potential benefits outweigh the costs. As pointed out in Chapter II, Brown and Yanuck have identified four key attributes that a system should have before the LCC concept should be applied to it. [Ref. 1:p. 4] These factors are: energy intensiveness, life expectancy, efficiency of operation and investment cost. Additionally, Graham has identified two other factors that should be considered. [Ref. 5:pp. 45-48] These are: availability of competition and mature design.

What is the Graham Life Cycle Costing Decision Model for Spare Parts?

The Graham LCC Decision Model for Spare Parts is an excellent qualitative decision model developed by Ruth Graham in 1988 intended to be used to identify those spare parts which lend themselves to the use of Life Cycle Costing. [Ref. 5:p. 6] As stated by Graham, the objective of the Graham LCC Decision Model is to " . . . provide contracting officers with a simple mechanism for determining if Life Cycle Costing methods should be applied to some specific spare part." [Ref. 5:p. 7] The first portion of Chapter IV provides a complete description of the Graham LCC Decision Model.

What modifications are required to adapt the Graham LCC Decision Model for Spare Parts to purchases of non-major systems by the NRCC, Detachment?

Table 2 located in Chapter IV provides a summary of the modifications made to the original Decision Model to adapt it for evaluating which non-major systems are LCC candidates. The four major alterations made by the researcher were: First, the minimum total procurement cost for the candidate was raised from $10,000 to $100,000. Second, a test to determine if the expected service life of the non-major system is greater than five years was added to the Model. Third, an examination to determine if the efficiency of operation of a given non-major system is an important consideration was added to the Decision Model. Finally, several decision characteristics related only to spare parts were eliminated from the Decision Model. A detailed discussion of the specific changes made to the original Graham LCC Decision Model is presented in Chapter IV.

Using the criteria specified in the Modified Graham Life Cycle Costing Decision Model for Non-Major Systems, what types of requirements procured by the NRCC, Detachment between 1 January 1990 and 16 January 1992 are valid candidates for Life Cycle Costing?

The process used by the researcher to select the valid LCC candidates purchased by the NRCC, Detachment is described in great detail in Chapter V. Through the use of the Modified Decision Model, five candidates were selected; these are listed below.

a. Nomenclature: Metal Shredder

Contractor: SSI Shredding Systems

	Quantity:	1 each
	Total Price:	$105,000
b.	Nomenclature:	Lightweight Portable Optical Tracking System
	Contractor:	KINTEC
	Quantity:	1 each
	Total Price:	$446,378
c.	Nomenclature:	Electric Motor
	Contractor:	Hansome Energy Systems, Inc.
	Quantity:	4 each
	Total Price:	$202,300
d.	Nomenclature:	Hoist Assembly for Weapons Elevator
	Contractor:	Harnischfeger Corp.
	Quantity:	1 assembly
	Total Price:	$422,000
e.	Nomenclature:	Shipboard Fire Detection System
	Contractor:	DYNALEC Corp.
	Quantity:	1 each
	Total Price:	$199,608.46

2. Answer to the Principal Research Question

Should the Naval Regional Contracting Center, Detachment, Long Beach apply the Life Cycle Costing concept to the acquisition of non-major systems in support of its customers?

As pointed out in Chapter V and Conclusion 1, the usefulness of the Life Cycle Costing concept for purchasing non-major systems at the NRCC, Detachment is very limited. This answer to the principal research question is based on the three criteria selected by the researcher to analyze the usefulness of LCC for procuring non-major systems at the NRCC, Detachment developed in Chapter V. These three criteria are discussed below. First, the researcher found that the number of valid LCC candidates purchased by the NRCC, Detachment to be too small to warrant the wholesale adoption of the Life Cycle Costing concept. Of the 1,495 contracts awarded from 1 January 1990 to 16 January 1992, the researcher found that only five acquisitions were for viable LCC candidates. Second, the researcher found that the two Government groups involved in the contracting process, the contracting officers and the customers, would need a significant amount of training and education to be able to confidently procure non-major systems using LCC techniques. Considering the small number of valid LCC candidates at the NRCC, Detachment, this effort would not be cost effective. Lastly, the researcher determined that the four major customers of the NRCC, Detachment face severe budget constraints; and, therefore, these commands are unwilling to spend more than is the minimum required to meet immediate needs. In other terms, the four major customers of the

NRCC, Detachment are unwilling to pay a larger initial procurement cost for a non-major system in return for reduced operations, support or maintenance cost in the future.

E. AREAS FOR FURTHER STUDY

1. Analyze each decision characteristic in the Modified Graham LCC Decision Model for Non-Major Systems in order to determine if any further changes should be made to improve the Model.

The researcher suggests that particular attention be given to two decision characteristics. The first is to investigate the minimum procurement cost of $100,000 to determine if this threshold can be improved. The second is the efficiency of operation characteristic; the primary aim would be to seek a means to possibly quantify the characteristic.

2. Conduct a study to determine the usefulness of the Modified Graham LCC Decision Model for Non-Major Systems at an Inventory Control Point.

As discussed earlier, possibly many of the requirements purchased by an ICP are ideally suited for the application of the LCC technique. However, the researcher is unaware of any efforts that have been made to determine whether this is the case or not.

3. Develop a quantitative Life Cycle Costing mathematical model tailored specifically for non-major systems.

This study would require the development of an entirely new LCC model designed specifically for non-major systems or would adapt an existing LCC model designed for major weapon systems, such as Dhillon's model discussed in Chapter II, to the procurement of non-major systems. The purpose of this study is to provide a means for the contracting officer to calculate the total LCC of each contractor's non-major system for contract award evaluation purposes.

4. <u>Perform a detailed cost benefit analysis on the cost effectiveness of applying Life Cycle Costing techniques at the field contracting level or at an Inventory Control Point</u>.

One specific area to investigate is to determine the true cost of implementing the Life Cycle Costing concept; these costs would range from training the contracting officers to an increase in the lead time required to purchase an item to overcoming any institutional resistance to the LCC concept. These costs would then be compared to the benefits of Life Cycle Costing, which range from a reduction in ownership cost to developing a clearer picture of precisely what the customer's requirements truly are.

5. <u>Conduct a case study of how Life Cycle Costing principles could be applied to the purchase of a particular non-major system</u>.

Only through the actual application of LCC to the purchase of a particular non-major system can all the potential problems and risks involved be recognized. Thus, this case study could be valuable in discovering those potential problems that an academic analysis would overlook.

APPENDIX A

LIST OF ABBREVIATIONS

ACRS	Accelerated Cost Recovery System
ADP	Automatic Data Processing
ASPR	Armed Services Procurement Regulation
CBS	Cost Breakdown Structure
CER	Cost Estimating Relationship
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DTLC	Design-for-Through-Life-Cost
FSC	Federal Supply Code
FY	Fiscal Year
LBNS	Long Beach Naval Shipyard, Long Beach, CA
LCC	Life Cycle Costing (Also, Life Cycle Cost)
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NASA	National Aeronautics and Space Administration
NRCC	Naval Regional Contracting Center
NSN	National Stock Number

NWAC	Naval Warfare Assessment Center, Corona, CA
NWS	Naval Weapons Station, Seal Beach, CA
O and M	Operations and Maintenance
OIC	Officer-In-Charge
PIIN	Procurement Item Identification Number
PCO	Procuring Contracting Officer
PMTC	Pacific Missile Test Center, Point Mugu, CA
RFP	Request For Proposal
SECDEF	Secretary of Defense
TINA	Truth In Negotiations Act of 1962
WBS	Work Breakdown Structure

APPENDIX B

COMMON LCC DEFINITIONS[3]

1. Analogy: a method of cost estimating on the basis of the similarities between two or more programs.

2. Availability: a measure of the probability of an item being in an operable state at an unknown (random) point in time.

3. Cost Drivers: the controllable design characteristics that have a predominant effect on a system's cost.

4. Cost Element: the building block of cost estimates; the individual cost, defined by all of the descriptors of cost, such as the subdivision of work, elements of cost, program phase, time and so on.

5. Cost Model: an approach, based on technical and programmatic parameters, for computing concerned costs.

6. Cost Estimating Relationship: an equation relating cost as the dependent variable to one or more independent variables.

7. Design To Cost: a management concept wherein rigorous cost goals are established during system development; and the control of system costs to those goals is achieved by practical trade-offs between operational capability, performance, cost and schedule.

8. Discounting: the method of computing the present worth of a future expenditure or income.

9. Failure: the termination of the ability of an item to carry out its stated mission or function.

10. Failure Rate: the number of failures of an item per unit measure of life (cycles, time, miles, events, and so on).

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[3]All definitions are from Reference 3:pp. 265-273 with the exception of definitions 5, 6, 9 and 28 which are from Reference 2:pp. 3-4.

11. Industrial Engineering Estimates: a cost estimate made by summing the cost estimates of the individual parts or components of the whole task; these individual estimates are often made by the persons who will do those component tasks. Also, known as grass roots or bottom up estimating.

12. Inflation: a period of rising prices for goods and services. It is measured as the ratio between the price of an item at one date and its price at a later date.

13. Integrated Logistics Support: a composite of all the support considerations necessary to assure the effective and economical support of a system for its Life Cycle. The principle elements of Integrated Logistics Support are: (a) the maintenance plan, (b) support and test plan, (c) supply support, (d) transportation and handling, (e) technical data, (f) facilities, (g) personnel and training, (h) logistic support resource funds and (i) logistics support management information.

14. Life Cycle Cost: the total cost for an item, which includes such costs as research and development, production, transportation, operation, support, maintenance, disposal and any other cost of ownership.

15. Life Cycle Costing: the consideration of total Life Cycle Costs in choosing between different courses of action.

16. Maintainability: a characteristic of design and installation that is expressed as the probability that an item will be retained in or restored to an operable condition within a specified period of time.

17. Maintenance: all action taken to retain material in a serviceable condition or to restore it to serviceability.

18. Mean Time Between Failures: the average time interval between item failures during the constant failure period of an item's life. It is measured by the total number of failures divided by the time interval; it is equal to the reciprocal of the failure rate.

19. Mean Time To Repair: the average time required to repair an item. It is measured by dividing the total corrective maintenance time by the total number of corrective maintenance actions during a given period of time.

20. Mission Need: a required capability within an agency's overall purpose, including cost and schedule considerations.

21. Model: a cost model is a set of mathematical rules and data to estimate costs based on technical and programmatic parameters.

22. Nonrecurring Costs: fixed costs, such as tooling, test equipment and planning, which are generally independent of the quantity to be produced or tested.

23. Operating and Support: the program phase during which the product is used. The phase is initiated by acceptance of the product and includes all operations, maintenance and modifications; these costs include charges for personnel, provisioning, fuel, support equipment and manuals for maintenance and operations.

24. Operating and Support Cost: those resources necessary to operate and support a system during its useful life.

25. Parametric Methods: estimating methods based on common attributes of two or more programs, such as weight, power or speed.

26. Present Value: the algebraic sum of the value of a stream of expenditures and/or income, discounted to the present time.

27. Recurring Costs: repetitive costs incurred for each item or each time period of production or test or use. Usually expressed as a cost per item or a cost per month.

28. Reliability: the probability that an item will carry out its mission satisfactorily for the desired period of time when used according to specified conditions.

29. Reliability Improvement Warranty: a contractual incentive for operational reliability and maintainability improvement providing for contractor repair of failed material over a stated period of time.

30. Risk: the possible variability in an estimate or plan expressed quantitatively or narratively; technical, schedule and cost risks are usually expressed quantitatively with limits at various probabilities.

31. Sensitivity Analysis: the determination of the impact on the final result of a change in the input variables, individually or in concert.

32. Should Cost: an estimate of costs based on an optimum situation envisioned by the cost analyst.

33. Sunk Cost: those expenditures already made or irrevocably committed.

34. System: a composite of equipment, skills and techniques capable of performing or supporting an operational role. Item levels from the simplest division to the more complex are: part, subassembly, assembly, unit, group, set, subsystem and system.

35. System Engineering: the process that transforms an operational need (mission requirement) into a description of a system performance parameters (design requirements) and a preferred system configuration.

36. Will Cost: an estimate of costs based on present institutional arrangements; the expected cost if the state of the world is not changed.

37. Work Breakdown Structure: a product-oriented family tree composed of hardware, services and data that results from project engineering efforts during the development and production of an item and that completely defines the product to be developed and produced and relates the elements of work to be accomplished to each other and to the end product.

APPENDIX C

LISTING OF THE 31 NON-MAJOR SYSTEMS

Appendix C is a listing of the 31 non-major systems selected from Reference 42 as possible candidates for use in the Modified Graham LCC Decision Model. Notice that the listing is in contract number sequence. The comments section consists of any important, interesting or noteworthy point observed by the author when researching the contract.

1. Contract Number: N00123-90-C-0012

   Award Date: 6 JAN 90

   Contractor: Maritime Power Corp.
   200 Henderson St.
   Jersey City, NJ 07302
   Telephone Number: 201-433-0870

   Customer: Long Beach Naval Shipyard
   Code 229.1
   Long Beach, CA 90822
   Telephone Number: 310-547-6871
   Designated for the USS Missouri (BB-63)

   Nomenclature: Generator, Diesel, Cooper Bessemer, Model FSN 6, 6 cycle, 900 rpm, 250 watt

   Quantity: 4 each

   Total Price: $107,800

Comments: The Diesel generators were to be installed in the reactivated Iowa class battleships. These generators were used to replace ones that were 40 years of age. The original manufacturers were unknown or no longer in business. Because of the early vintage of the equipment, modern Diesel generators do not meet fit, form or function requirements. Moreover, this was an urgent requirement that was needed within 15 days of contract award.

2. Contract Number: N00123-90-C-0040

Award Date: 14 MAR 90

Contractor: Isothermal (USA) Ltd.
250 West 57th St.
New York, NY 10107
Telephone Number: 212-765-5290

Customer: Naval Weapons Station
Building 239, Code 1121
Seal Beach, CA 90740
Telephone Number: 310-594-7368

Nomenclature: Temperature Calibration System

Quantity: 1 assembly

Total Price: $105,425

Comments: The Temperature Calibration System was to be used to calibrate temperature indicating instruments from 182 degrees Celsius to 1000 degrees Celsius.

3. Contract Number: N00123-90-C-0044

Award Date: 15 MAR 90

Contractor: SSI Shredding Systems
28655 SW Boones Ferry Rd.
Wilsonville, OR 97070
Telephone Number: 503-682-3633

Customer: Naval Weapons Station
Building 239, Code 1122
Seal Beach, CA 90740
Telephone Number: 310-594-7368

Nomenclature: Metal Shredder. 150 hp, capable of shredding 3/16 inch flat stock mild steel

Quantity: 1 each

Total Price: $105,000

Comments: Nine manufacturers submitted bids for this item.

4. Contract Number: N00123-90-C-0108

Award Date: 7 MAR 90

Contractor: Superior-Lidgerwood-Mundy Corp.
1101 John Ave.
Superior, WI 54880
Telephone Number: 715-394-4444

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Tarawa (LHA-1)

Nomenclature: Gypsy Winch

Quantity: 2 assemblies

Total Price: $97,132

Comments: The gypsy winch assemblies are new to the Navy and will be used to retrieve landing craft. The assemblies specified are entirely proprietary to Superior-Lidgewood-Mundy Corp. The information as spelled out in the plans contain no engineering specifications for competition. The cost of providing plans that contain engineering data for each ship would be great.

5. Contract Number: N00123-90-C-0126

Award Date: 4 SEP 90

Contractor: KINTEC
12205 28th St. N.
St. Petersburg, FL 33716
Telephone Number: 813-573-7866

Customer: Navai Weapons Station
Building 239, Code 1142
Seal Beach, CA 90740
Telephone Number: 310-594-7368

Nomenclature: Lightweight Portable Optical Tracking System

Quantity: 1 each

Total Price: $446,378

Comments: None

6. Contract Number: N00123-90-C-0273

Award Date: 8 AUG 90

Contractor: Welch Ally, Inc.
Jordan Rd.
Skaneateles Falls, NY 13153
Telephone Number: 315-685-3172

Customer: Naval Air Rework Facility
Building 90-2, Code 21403
NAS North Island
San Diego, CA 92135
Telephone Number: 619-437-7048

Nomenclature: Bar Coding Equipment

Quantity: 1 set

Total Price: $76,325

Comments: Many bids were submitted for this contract.

7. Contract Number: N00123-90-C-0344

Award Date: 13 SEP 90

Contractor: Fryer Machine Systems
56 Lafayette Ave.
White Plains, NY 10603
Telephone Number: 914-428-8877

Customer: Naval Undersea Warfare Engineering Activity
Building 5000, Code 32
Keyport, WA 98345
Telephone Number: 206-728-3376

Nomenclature: Milling Machine

Quantity: 1 each

Total Price: $34,900

Comments: None

8. Contract Number: N00123-90-C-0376

Award Date: 9 JUL 90

Contractor: Hansome Energy Systems, Inc.
365 Dalziel Rd.
Linden, NJ 07036
Telephone Number: 908-862-9044

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Belleau Wood (LHA-3)

Nomenclature: Electric Motor, 350 hp

Quantity: 4 each

Total Price: $202,300

Comments: None

9. Contract Number: N00123-90-C-0416

Award Date: 21 FEB 90

Contractor: M.T. Davidson Co.
1101 John Ave.
Superior, WI 54888
Telephone Number: 715-394-4444

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for: USS Reeves (CG-24)
USS Josephus Daniels (CG-27)
USS Sterett (CG-31)
USS William H. Stanely (CG-32)

Nomenclature: Water Circulating Pump

Quantity: 10 each

Total Price: $174,250

Comments: The M.T. Davidson Co. holds proprietary rights to these pumps which are required to complete a pending NAVSEA Ship Alteration. Moreover, M.T. Davidson is the only source to express interest in this item.

10. Contract number: N00123-90-C-0543

Award Date: 1 AUG 90

Contractor: Tenney Engineering, Inc.
1090 Springfield Rd.
Union, NJ 07083
Telephone Number: 201-686-7870

Customer: Naval Postgraduate School
Code 4222
Monterey, CA 93943
Telephone Number: 408-646-2970

Nomenclature: Thermal Vacuum Space Simulator System

Quantity: 1 each

Total Price: $49,060

Comments: Tenney Engineering is the sole manufacturer of the equipment required to meet the school's needs.

11. Contract Number: N00123-90-C-0622

Award Date: 14 SEP 90

Contractor: Superior-Lidgerwood-Mundy Corp.
1101 John Ave.
Superior, WI 54880
Telephone Number: 715-394-4444

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Belleau Wood (LHA-3)

Nomenclature: Gypsy Winch

Quantity: 2 assemblies

Total Price: $105,606

Comments: See contract number N00123-90-C-0108 for explanation.

12. Contract Number: N00123-90-C-0737

Award Date: 4 OCT 90

Contractor: M.T. Davidson Co.
1101 John Ave.
Superior, WI 54880
Telephone Number: 715-394-4444

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Taylor (FFG-50)

Nomenclature: Water Circluating Pump

Quantity: 2 each

Total Price: $33,130

Comments: See contract number N00123-90-C-0416 for explanation.

13. Contract Number: N00123-90-C-0838

Award Date: 28 SEP 90

Contractor: IAP, Inc.
P.O. Box 56
HWY 13 South
Phillips, WI 54555
No telephone number available

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the deactivation of the USS New Jersey (BB-62)

Nomenclature: Fan, centrifugal, 5,000 cfm

Quantity: 15 each

Total Price: $102,780

Comments: The fans were an urgent requirement to continue the USS New Jersey deactivation. Specifically, the fans were to be used to ventilate and gas free tanks and voids. Failure to quickly procure the fans would have resulted in an unavoidable work stoppage costing an estimated $30,000 per day.

14. Contract Number: N00123-91-C-0052

Award Date: 1 MAR 91

Contractor: Cook Brothers Manufacturing
1030 Calle Recodo
San Clemente, CA 92672
Telephone Number: 714-361-8767

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Belleau Wood (LHA-3)

Nomenclature: Butterfly Valve

Quantity: 5 each

Total Price: $54,400

Comments: This was an urgent requirement for the overhaul of the USS Belleau Wood (LHA-3).

15. Contract Number: N00123-91-C-0228

Award Date: 25 JUN 91

Contractor: Brandon Industrial
14120 Gannet St.
Santa Fe Springs, Ca 90670
Telephone Number: 213-921-0407

Customer: Long Beach Naval Shipyard
Code 229
Long Beach, CA 90822
Telephone Number: 310-547-6871

Nomenclature: Pumps, centrifugal, with electric motor

Quantity: 6 each

Total Price: $56,614.50

Comments: These pumps were urgently required to maintain the Long Beach Naval Shipyard's dry dock certification. The pumps were required within six weeks to remove toxic waste materials from the dry dock.

16. Contract Number: N00123-91-C-0234

Award Date: 29 MAY 91

Contractor: Alpha Technical Services, Inc.
33 Donald Dr.
Fairfield, OH 45014
Telephone Number: 513-829-0999

Customer: Long Beach Naval Shipyard
Code 229
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Oldendorf (DD-972)

Nomenclature: Bridge Crane Assembly

Quantity: 1 assembly

Total Price: $44,598

Comments: None

17. Contract Number: N00123-91-C-0317

Award Date: 9 JUL 91

Contractor: Communication Satellite Corp.
22300 Comsat Dr.
Clarksburg, ML 20871
Telephone Number: 301-428-5044

Customer: Naval Postgraduate School
Code 4222
Monterey, CA 93943
Telephone Number: 408-646-2970

Nomenclature: Spacecraft Attitude Control Simulator

Quantity: 1 each

Total Price: $79,664

Comments: Communication Satellite was the only known contractor that already had the specialized knowledge required to produce this item. The Government estimated that the development cost for a second contractor to produce this item would be no less than $1,000,000.

18. Contract Number: N00123-91-C-0402

Award Date: 15 MAR 91

Contractor: Harnischfeger Corp.
Governments Products
P.O. Box M-2015
Milwaukee, WI 53201
Telephone: 414-764-8531

Customer: Long Beach Naval Shipyard
Code 229
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Peleliu
(LHA-5)

Nomenclature: Hoist Assembly for Weapons Elevator

Total Price: $422,000

Comments: None

19. Contract Number: N00123-91-C-0468

Award Date: 22 MAY 91

Contractor: Radian Technology
4211 Burton Dr.
Santa Clara, CA 95054
Telephone Number: 408-980-9877

Customer: Pacific Missile Test Center
Code 4071
Point Mugu, CA 93042
Telephone Number: 805-989-5987

Nomenclature: Radar Receiver

Quantity: 1 each

Total Price: $696,000

Comments: This item is a new development; no reliability data has yet been recorded for it.

20. Contract Number: N00123-91-C-0483

Award Date: 26 SEP 91

Contractor: Loral Terracom
9020 Balboa Ave.
San Diego, CA 92123
Telephone Number: 619-278-4100

Customer: Naval Warfare Assessment Center
Code 1142
Corona, CA 91720
Telephone Number: 714-273-4451

Nomenclature: Power Amplifier, 2 Ghz, 10 watt

Quantity: 1 each

Total Price: $66,477

Comments: Loral Terracom is the original equipment manufacturer and possesses proprietary data rights to the system; thus, this was a sole source purchase.

21. Contract Number: N00123-91-C-0594

Award Date: 24 SEP 91

Contractor: UNARCO Material Handling
12022 Parklawn Dr.
Rockville, MD 20852
Telephone Number: 301-770-4000

Customer: Naval Weapons Station
Building 10, Code 0522
Seal Beach, CA 90740
Telephone Number: 310-594-7368

Nomenclature: Material Handling System

Quantity: 1 each

Total Price: $50,064

Comments: None

22. Contract Number: N00123-91-C-0724

Award Date: 9 AUG 91

Contractor: Maxiran Corp.
5841 N. HWY 441
Ocala, FL 32670
Telephone Number: 904-629-8044

Customer: Naval Warfare Assessment Center
Code 1142
Corona, CA
Telephone Number: 714-736-4363

Nomenclature: Medium Range Navigation System

Quantity: 1 each

Total Price: $215,867

Comments: None

23. Contract Number: N00123-91-C-0725

Award Date: 9 AUG 91

Contractor: Chromalox
E.I. Wiegand Div. of Emerson
Electric Co.
12300 E. Washington Blvd., Suite J
Whittier, CA 90606
Telephone Number: 310-945-8303

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Puller
(FFG-25)

Nomenclature: Auxiliary Boiler, Laundry, 440 volt,
3 phase, 60 Hz, 300 kw, Emerson
Electric, NSN: 1HS 4410-01-249-0726

Quantity: 1 each

Total Price: $31,740

Comments: While the boiler does have a National Stock Number (NSN), it is a made-to-order, long lead time item available only from a sole source manufacturer and is not stocked in the Navy Supply System. The item manager approved the local procurement.

24. Contract Number: N00123-92-C-0060

Award Date: 1 OCT 91

Contractor: Oceanographic Instrument Systems
13 County Rd., P.O. Box 766
N. Falmouth, MA 02556
Telephone Number: 508-564-5061

Customer: Naval Postgraduate School
Code 2221

Monterey, Ca 93943
Telephone Number: 408-646-2970

Nomenclature: Benthic Acoustic Stress Sensor System

Quantity: 1 each

Total Price: $28,085

Comments: Extensive market research revealed that only Oceanographic Instrument Systems holds the patent rights to this type of system.

25. Contract Number: N00123-92-C-0079

Award Date: 10 OCT 91

Contractor: FSE, Inc.
911 S. Anderson Dr.
Escondido, CA 92029
Telephone Number: 619-747-2107

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Peleliu
(LHA-5)

Nomenclature: Baking and Roasting Ovens, forced convection, electric

Quantity: 7 each

Total Price: $48,888

Comments: This was an urgent request which needed to be filled within eight weeks.

26. Contract Number: N00123-92-C-0087

Award Date: 11 OCT 91

Contractor:	Crane Defense Systems Rt. 20, Box 1126 Cronroe, TX 77301 Telephone Number: 409-539-4545
Customer:	Long Beach Naval Shipyard Code 229.1 Long Beach, CA 90822 Telephone Number: 310-547-6871 Designated for the USS Oldendorf (DD-972)
Nomenclature:	Torpedo Adapter Assembly
Quantity:	1 assembly
Total Price:	$55,541

Comments: This was an unique item for the USS Oldendorf. Previously, the LBNS had fabricated a similar, smaller assembly in 1989. Crane Defense Systems proved to be the only commercial source for this assembly.

27.	Contract Number:	N00123-92-C-0089
	Award Date:	30 MAR 91
	Contractor:	DYNALEC Corp. 87 West Main St. Sodus, NY 14551 Telephone Number: 315-483-6923
	Customer:	Long Beach Naval Shipyard Code 229.1 Long Beach, CA 90822 Telephone Number: 310-547-6871 Designated for the USS Peleliu (LHA-5)
	Nomenclature:	Shipboard Fire Detection System
	Quantity:	1 each

Total Price: $199,608.46

Comments: None

28. Contract Number: N00123-92-C-0110

Award Date: 19 NOV 91

Contractor: Keystone Inc.
1701 E. Monticello Ct.
Ontario, CA 91761
Telephone Number: 714-699-3225

Customer: Long Beach Naval Shipyard
Code 229.1
Long Beach, CA 90822
Telephone Number: 310-547-6871
Designated for the USS Peleliu
(LHA-5)

Nomenclature: Butterfly Valves

Quantity: 35 each

Total Price: $38,955

Comments: These valves were an urgent requirement to complete work on this ship's fuel oil system.

29. Contract Number: N00123-92-C-0134

Award Date: 21 NOV 91

Contractor: TEKTRONIX
14150 S.W. Kaul Braun
P.O. Box 500
Beaverton, OR 97077
Telephone Number: 714-660-8080

Customer: Naval Postgraduate School
Code 4222

		Monterey, CA 93945 Telephone Number: 408-646-3067
	Nomenclature:	Oscilloscope, 1 Ghz bandwidth, color display
	Quantity:	1 each
	Total Price:	$27,505.19
	Comments: None	
30.	Contract Number:	N00123-92-C-0149
	Award Date:	21 NOV 91
	Contractor:	Coherent, Inc. 3270 W. Bayshore Palo Alto, CA 94303 Telephone Number: 415-852-3642
	Customer:	Long Beach Naval Hospital 7500 E. Carson St. Long Beach, CA 90822 Telephone Number: 310-420-5249
	Nomenclature:	Laser
	Quantity:	1 assembly
	Total Price:	$32,849.96
	Comments: None	
31.	Contract Number:	N00123-92-C-0160
	Award Date:	11 DEC 91
	Contractor:	Litton Systems, Inc. AMECON Division 5115 Calvert Rd.

College Park, MD 20740
Telephone Number: 301-864-5600

Customer:	Long Beach Naval Shipyard Code 229.1 Long Beach, CA 90822 Telephone Number: 310-547-6871 Designated for the USS Oldendorf (DD-972)
Nomenclature:	Damage Control Console and Fuel Control Console
Quantity:	1 kit
Total Price:	$40,213

Comments: None

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33. Personal Interview with Mary O'Brien, Contracting Officer, Naval Regional Contracting Center, Detachment, Long Beach, CA, 17 January 1992.

34. Personal Interview with Dorothy Rodgers, Contracting Officer, Naval Regional Contracting Center, Detachment, Long Beach, CA, 17 January 1992.

35. Telephone Conversation Between Larry Blanke, Systems Engineer, KINTEC Corp. of St. Petersburg, FL and author on 2 March 1992.

36. Telephone Conversation Between Leonard Johnson, Electrical Engineer, Radian Technology of Santa Clara, CA and author on 27 February 1992.

37. Telephone Conversation Between Tom Krauss, Sales Representative, Hansome Energy Systems, Inc. of Linden, NJ and author on 27 February 1992.

38. Telephone Conversation Between James Lassiter, Owner, Maxiram Corp. of Ocala, FL and author on 27 February 1992.

39. Telephone Conversation Between Richard Mead, Marketing Specialist, SSI Shredding Systems of Wilsonville, OR and author on 28 February 1992.

40. Telephone Conversation Between Henry Sostmann, Chief Designer, Isothermal (USA) Limited of New York, NY and author on 27 February 1992.

41. Telephone Conversation Between John Switzer, Sales Representative, DYNALEC Corp. of Sodus, NY and author on 27 February 1992.

42. Telephone Conversation Between Frank Tutschy, Engineer, Harnischfeger, Corp. of Milwaukee, WI and author on 27 February 1992.

43. Computer listing of all contracts awarded by the Naval Regional Contracting Center, Detachment, Long Beach, CA from 1 January 1990 to 16 January 1992. This report was generated by Mr. J.D. Upshaw, Computer Systems Analyst, ADP Department, NRCC, Detachment, Long Beach, CA for the researcher on 16 January 1992. The computer listing contains the following data elements: Schedule Number, Document Number, Contractor, Description, Federal Supply Code (FSC) and Date Executed.

44. Telephone Conversation Between Chuck Christman, Electrical Engineer, Naval Warfare Assessment Center, Corona, CA and author on 11 March 1992.

45. Telephone Conversation Between Anthony Comres, Contracts Branch Head, Long Beach Naval Shipyard, Long Beach, CA and author on 11 March 1992.

46. Telephone Conversation Between Marty Daugherty, Contracts Specialist, Naval Weapons Station, Seal Beach, CA and author on 11 March 1992.

47. Telephone Conversation Between Peter Marvin, Target Projects Head, Pacific Missile Test Center, Point Mugu, CA and author on 11 March 1992.

48. Telephone Conversation Between Charles Query, Ordnance Production Superintendent, Naval Weapons Station, Seal Beach, CA and author on 12 March 1992.

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