





DEPARTMENT OF NATIONAL DEFENCE  
CANADA



OPERATIONAL RESEARCH AND ANALYSIS  
DIRECTORATE OF LOGISTICS ANALYSIS

D Log A Research Note 95/1

**LIFE CYCLE COSTING**

by

M. Provencher

**FEBRUARY 1995**

The contents are the responsibility of the authors and publication by the Directorate of Logistics Analysis does not necessarily reflect the official position of the Canadian Department of National Defence

OTTAWA, CANADA



National  
Defence

Défense  
nationale

## Operational Research and Analysis

### CATEGORIES OF PUBLICATION

ORA Reports are the most authoritative and most carefully considered publications of the Establishment. They normally embody the results of major research activities or are significant works of lasting value or provide a comprehensive view on major defence research initiatives. ORAE Reports are approved by DGOR and are subject to peer review.

ORA Project Reports record the analysis and results of studies conducted for specific sponsors. This category is the main vehicle to report completed research to the sponsors and may also describe a significant milestone in ongoing work. They are approved by DGOR and are subject to peer review. They are released initially to sponsors and may, with sponsor approval, be released to other agencies having an interest in the material.

Directorate Research Notes are issued by directorates. They are intended to outline, develop or document proposals, ideas, analysis or models which do not warrant more formal publication. They may record development work done in support of sponsored projects which could be applied elsewhere in the future. As such they help serve as the corporate scientific memory of the directorate.

## **FOREWORD**

For several years now, the Directorate of Logistics Analysis (D Log A) has been giving a one-hour course on the subject of Life Cycle Costing at the Material Management Training Centre (MMTC) for the Life Cycle Material Managers (LCMM). A substantial review of the content of this course was recently done and I thought it useful to share it with a broader audience.



### **ABSTRACT**

This report explains what Life Cycle Costing is, why it is important, and how one can apply it. It is a concise yet complete review of the subject.

### **RÉSUMÉ**

Ce document explique ce qu'est l'analyse du coût du cycle de vie, pourquoi cette analyse est importante, et comment elle est appliquée. C'est une revue complète mais concise du sujet.



**TABLE OF CONTENTS**

	<b><u>Pages</u></b>
Foreword.....	i
Abstract/Résumé.....	ii
Table of Contents.....	iii
Acknowledgement.....	iv
What is Life Cycle Costing?.....	1
Why do LCC?.....	2
How to do LCC?.....	6
LCC Estimation.....	7
Analogy.....	8
Parametric.....	9
Engineering.....	10
Data Sources.....	13
Conclusion.....	13
References.....	14



## ACKNOWLEDGEMENT

I would like to thank Ivan Taylor and Michel Vigneault whose useful comments have improved the content of this presentation.



## LIFE CYCLE COSTING

### WHAT IS LIFE CYCLE COSTING?

1. Life Cycle Costing (LCC) is the study of all the relevant costs of an equipment or system which are incurred over its expected life cycle. The main objective of LCC is to achieve the lowest total ownership costs while maintaining mission effectiveness goals.
2. While the concept of Life Cycle Costing is simple enough, its application often seems difficult because it cuts across traditional disciplines and functions, it demands data from sources designed for different purposes, and it often requires methods of analysis that have not been tried before. We will try to demystify these perceptions. The ultimate goal here is to help you make better decisions.
3. First a little bit on the historic side of LCC. Until the late 1960's, the capital component of procurement dominated the cost of ownership. Consequently, acquisition decisions were based primarily on capital costs. As system complexity increased and the demand for technical skills in maintenance grew, the cost of operations and maintenance assumed a greater proportion of the cost of ownership. By the late sixties, the resources necessary to support weapon systems were of increasing concern to defence organizations of the major western powers.
4. In that same period, the U.S. Department of Defense (DOD) issued several policy directives aimed at instituting life cycle costs, rather than acquisition costs, as the focus for procurement. In Great Britain, both the Royal Navy and the Royal Air Force have concentrated on the isolation of cost drivers in supportability and on taking corrective action. In 1975, Canada's Treasury Board, directed that life cycle costs rather than acquisition costs would be the determining factor in all government procurement. In the 1980's, Treasury Board strengthened its position that investment decisions be backed by LCC analysis. Continuing government trends to decrease spending and a "value for money" philosophy boosted the importance of LCC.
5. The Department of National Defence became strongly involved in LCC in 1975 and initiated several projects, including the development of a costing model by Bell Northern Research. An improved PC version of this model is available from D Log A.

### WHY DO LCC?

6. There are two basic objectives in doing Life Cycle Costing. One is budgeting, the other is decision making. D Cost S can help you with your budget estimates. We at D Log A concentrate on using LCC for decision making.

7. Life Cycle Costing shows that beyond the acquisition cost there are other costs such as Operations and Support (O&S) costs which can be much more significant (see Figure 1). This implies that the greatest potential opportunity for cost reduction is in controlling the high cost of system support. Since there are always alternative equipment designs and maintenance concepts, there is a need to ensure that the accepted design and concept will not incur excessive O&S costs. This sometimes means spending more on Research and Development (R&D) to improve reliability or maintainability. The timing of that effort however is sensitive to the evolution of the design.

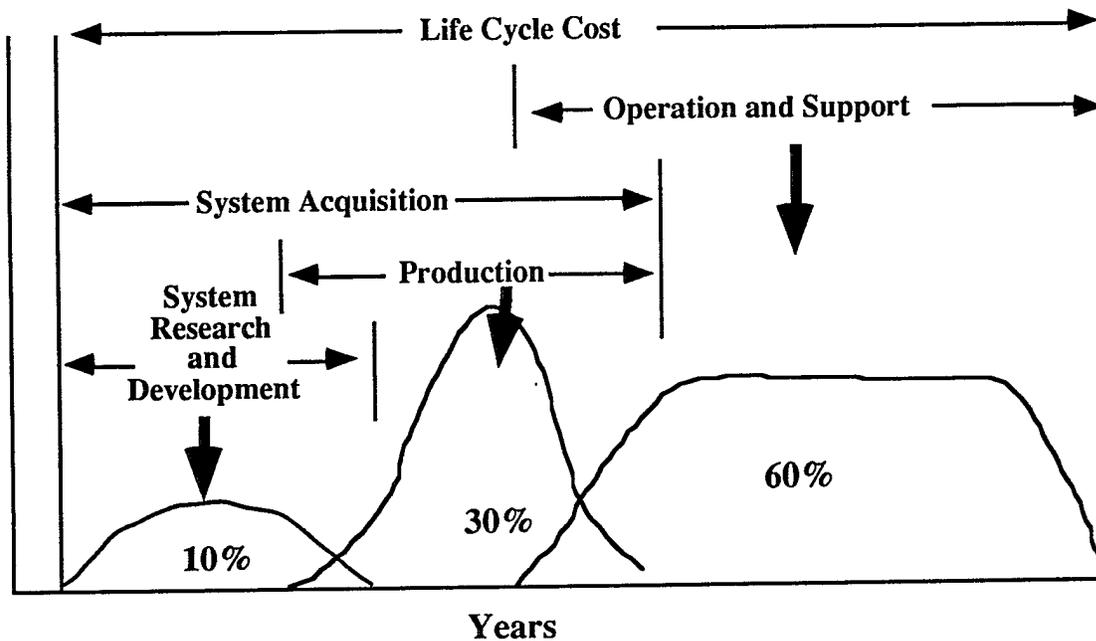
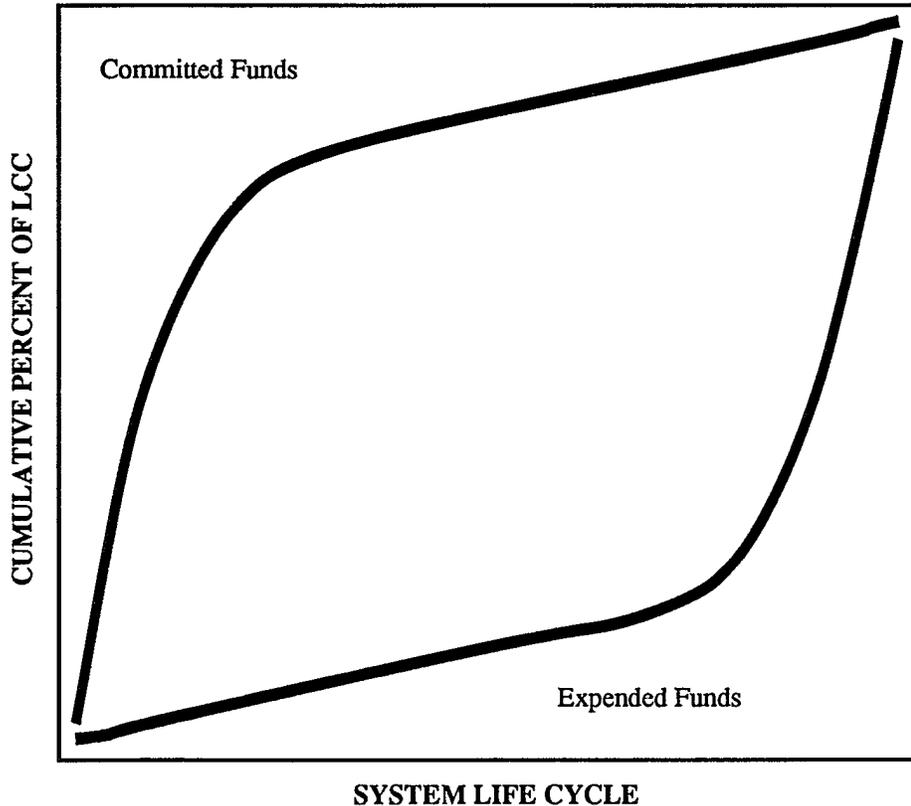


Figure 1: Nominal Cost Distribution of a typical DND program

8. Figure 2 depicts the opportunity for reducing costly design concepts. As illustrated by the figure, efforts to minimize life cycle costs are most effective in the conceptual and early design stages when alternatives are being identified and selected. Reliability and Maintainability (R&M) are the support's prime cost drivers. Because R&M parameters are design dependent, the lower limit of potential life cycle cost range becomes fixed very early in the acquisition phase.



**Figure 2: Effect of early decisions on LCC**

9. LCC is not only useful at the beginning of a capital project for the selection between contractors. It can be used as a decision tool when aging equipment needs to be replaced. As an equipment ages, the support of that equipment tends to become increasingly expensive. At some point in time, a decision must be made to either rebuild/refit the equipment or explore alternative methods of meeting the operational requirement. This decision is necessary when it has been determined that the present system either cannot meet the operational needs or the support costs are too great to continue carrying the present

system in the DND inventory. Life Cycle Cost Analysis can be used to address the three possible options available in resolving this scenario. The first possibility is to examine the support costs being incurred and determine if these costs may be reduced through the use of more advanced maintenance techniques or better support concepts. The second possibility is to determine the benefits which may be realized by performing a rebuild/refit on the system to incorporate subsystems which will reduce the maintenance and support system demands. The last possibility is to assess the impact on support system resource demands which may result from replacing the old system with a new system. As shown in Figure 3, the best time to replace an equipment is when the average annual cost of ownership is at a minimum.

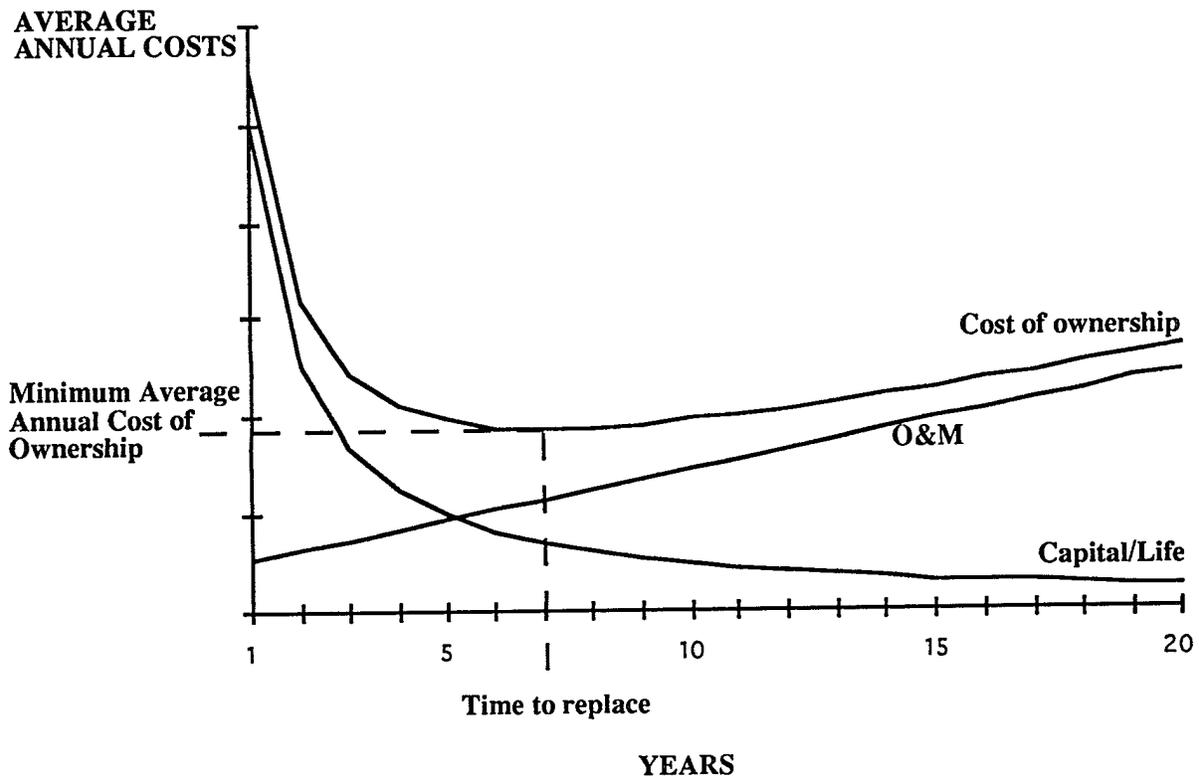


Figure 3: Options regarding aging equipment

10. LCC analysis can be used to determine how long it will take to get back an investment that you have made. This type of payback analysis can be very useful in selling

an equipment modification program which might cost some money today but result in lower O&M (Operations & Maintenance) costs in the future. In Figure 4, we see an investment of \$15,000. today and additional \$6,000. and \$3,000. at the end of year 1 and 2. The savings begin to be realized in year 2 (\$5,000.) and year 3 (\$12,000.). By midway through year 4 we reach a payback point and in subsequent years additional savings are realized.

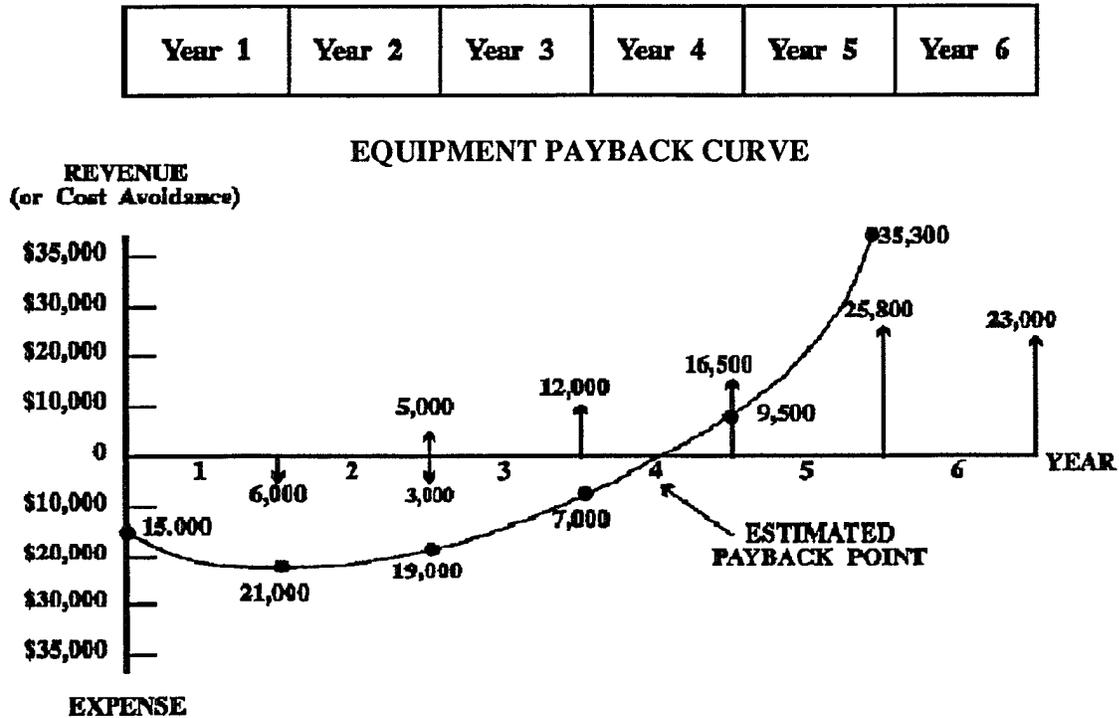


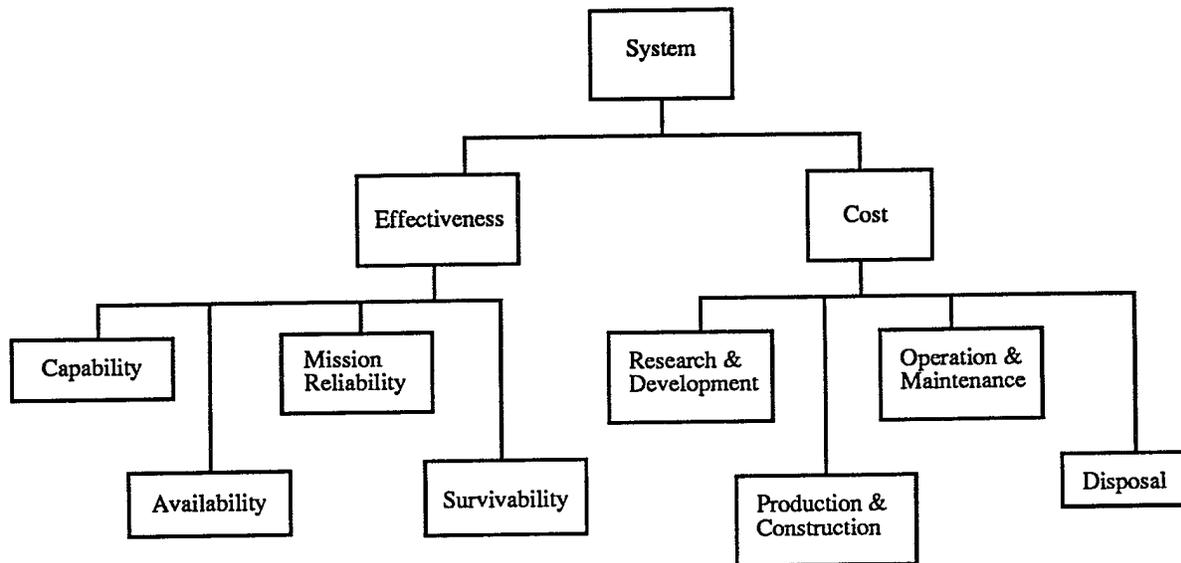
Figure 4: Payback Analysis

11. In essence, the Life Cycle Costing approach provides the life cycle manager with the tools required to make sound, rational decisions to determine which of the possible alternatives under consideration is the most cost effective.

12. However, cost is not a measure of quality. For specified equipment performance levels, Life Cycle Costing determines who does it at the best cost. But given that the requirements are met, we should also ask ourselves: who gives the best bang for the buck?

## HOW TO DO LCC?

13. When making a decision on an equipment or system, we should keep in mind its cost and its effectiveness. Figure 5 illustrates the important factors.



**Figure 5: LCC considerations**

14. This hierarchy can be broken down further. For example, capability can be divided into individual missions or roles. Operations and Maintenance can be broken down to Fuel, Spares, Maintenance Manpower, Training, etc. Note that Disposal can be a cost or a benefit (negative cost) depending on the situation under study. For example, the disposal of equipment with PCB components may involve a considerable expense. However, the resale value of an automobile may be a benefit.

15. In developing a cost projection, there are several different procedures that may be used. Here is a general outline of activities that should take place to complete a successful LCC analysis:

- a. identify all relevant activities throughout the Life Cycle that will generate costs;

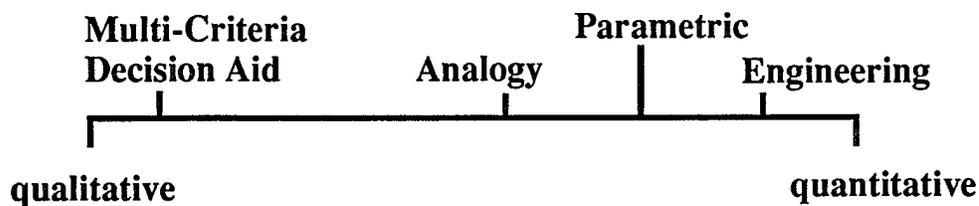
- b. identify the mission factors that should be considered to measure effectiveness;
- c. develop a cost breakdown structure which describes the total system cost and ensures that all relevant costs are counted but only counted once;
- d. develop measures of effectiveness by which the alternatives can be compared;
- e. identify and measure the high cost contributors (drivers); and
- f. use the cost drivers and effectiveness measures to do trade-offs and determine the most cost-effective decision.

16. This approach is based on the well established Pareto principle or 80/20 ratio. That is, for any system, 80% of the LCC will be accounted for by 20% of the cost elements. In turn, 80% of the effort in the study should be placed on the detailed analysis of this 20%.

### **LCC ESTIMATION**

17. Life Cycle Cost estimating is the calculation of costs before they are incurred. No matter how detailed the calculation, it must be emphasized that the results are only estimates and these estimates may vary widely in accuracy when related to the real costs eventually incurred.

18. Life Cycle Costs may be estimated using a variety of methods, some having stronger mathematical bases than others.



**Figure 6: Estimating Methods**

19. When using people's expertise and few numbers, Multi-Criteria Decision methods are very useful. With more information on the system, analogy, parametric, and engineering methods can be used (Figure 6). We will concentrate on the latter methods whereas Multi-Criteria Decision Making will be explained in the case study [5].

### **Analogy**

20. Cost estimating by analogy uses the life cycle costs of similar systems as the basis for determining the LCC for a new system. This method is normally used during the initial phases of a project when there is very little detailed knowledge of the proposed system. The system under analysis must be close in design, operational use and maintenance concept to a known system. The degree to which the two systems are similar is a matter of analysis for the decision maker, who must evaluate the differences and determine what effect, if any, these differences would have on life cycle costs.

21. The principle of cost estimating by analogy is shown in the following equation:

$$\text{Proposed System Cost} = \text{Factor} \times \text{Similar System Cost} + \text{Adjustment}$$

The factor handles inflation, foreign currency exchange rate, etc. The adjustment compensates for known variances between the two systems. It is important to choose a system which is similar enough to the new system and which has enough LCC data available to provide a reasonable baseline for the LCC estimate.

22. An example of this cost estimating method is the costing of a new tank, as illustrated in Figure 7. Many systems such as engine, suspension and gun may be so similar to the current tank systems that the LCC figures for the current tank system may be used to calculate that portion of the system cost. However, the technological differences associated with developing a digital/laser fire control system as compared to a mechanical/optical system as found on the old tank are quite significant and require an adjustment for that portion of the costing of the new tank weapon system.

## COSTING BY ANALOGY

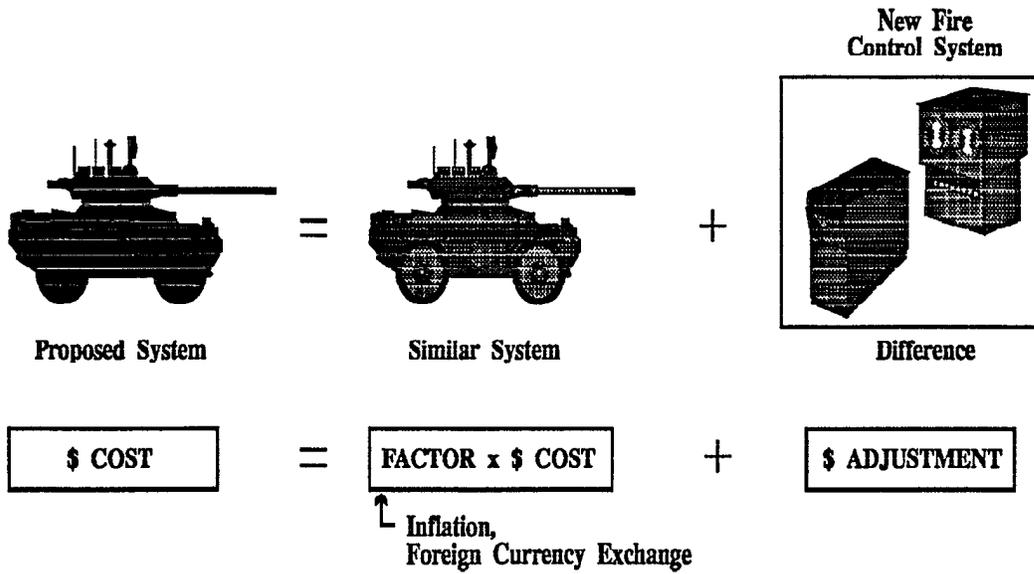


Figure 7: Costing by Analogy

Parametric

23. Parametric estimating is a method which uses a system performance or physical characteristic as the means to predict LCC. Many systems have a direct relationship between one or more of its major parameters and its overall cost. For example, cost may be expressed as a function of system's weight.

24. Traditionally, this costing method has been used mainly for estimating acquisition costs, such as for aircraft which have been priced on a dollar per kilogram basis. The aircraft's weight is determined early in the concept phase by initial design studies or by specification. The estimating relationship may be a simple linear function depicted graphically as in Figure 8 and identified by the following equation:

$$\text{cost} = \text{weight} \times \text{cost/kilogram.}$$

## PARAMETRIC COST ESTIMATING

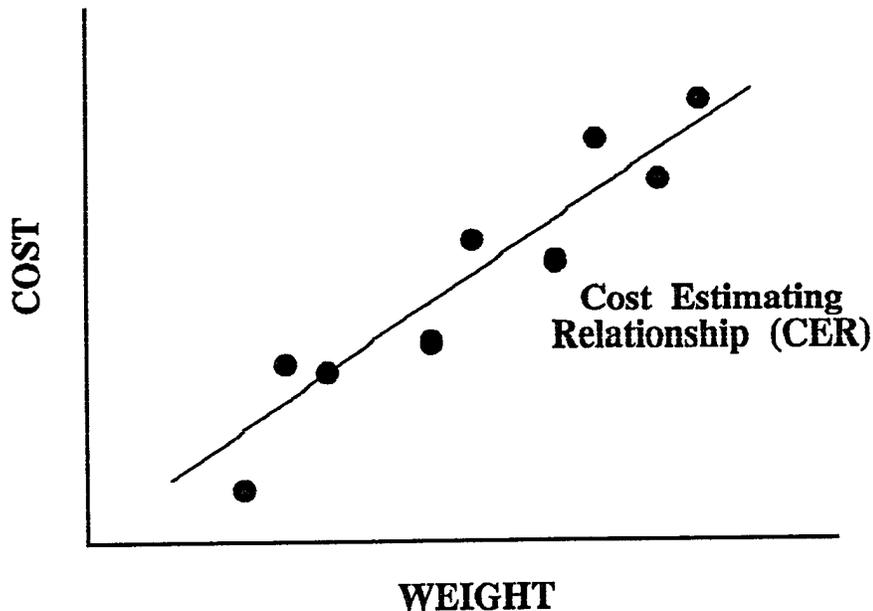


Figure 8: Parametric Cost Estimating

25. The important factor in using this method is that there must be a real relationship between the parameter chosen and cost. This relationship is established by gathering cost data on a large number of projects on an on-going basis over many years. The cost data are organized into a database and comparisons between costs and physical parameters are made. The result is a set of equations that define a cost estimating relationship between the parameters and the cost. This approach has been used successfully in the US where there are many acquisition programs in the database. There is no equivalent database of Canadian acquisitions. Examples of parametric models are: GE PRICE, CAAMS, and COCOMO (for software CER).

### Engineering

26. Engineering cost estimates are based upon system and process knowledge. They are built "from the bottom up", based on available design and manufacturing data which allows for a cost breakdown. This type of estimate will provide the most detailed costing estimates of the three methods described here provided detailed data is available. These estimates can also be made when less information is available but the estimates are

correspondingly less accurate. An example of costing using this technique is provided in Figure 9. We have an excellent engineering type LCC model, called LOGAN(LCC), built specifically for DND and supported by D Log A. LOGAN(LCC) also does risk analysis on the life cycle cost of a project. CASA is another example of engineering model.

RECURRING:		\$ 11.127010 M/YEAR
OPERATING:		\$ 8.229997
MAINTENANCE:		\$ 2.074919
CONSUMABLES:		\$ 1.733972
MANPOWER:		\$ .181621
SCHED. REPAIR:	\$ .034466	
PE REPAIR:	\$ .062940	
1ST REPAIR:	\$ .039256	
2ND REPAIR:	\$ .015397	
3RD REPAIR:	\$ .029562	
MAINTENANCE TRAINING:	\$ .008185	
CONTRACTOR REPAIR:	\$ .026017	
TE EQPT MAINTENANCE:	\$ .001200	
MAINT DOC. UPDATE:	\$ .123923	
OTHER COSTS:	\$ .000000	
SUPPLY SUPPORT:		\$ .822095
SPARES REPLACEMENT:	\$ .178794	
TRANSPORT:	\$ .641919	
DOCUMENTATION:	\$ .001382	
OTHER COSTS:	\$ .000000	
OTHER RECURRING COSTS:		\$ .000000

**Figure 9: Engineering Method For Costing**

27. When making a decision based on LCC, there may be a lot of "what if" questions that come to mind. A thorough presentation should address as many of these as possible. The study of these "what if" questions is called sensitivity analysis. A particular parameter is systematically varied, so that its effect on the cost elements can be examined. This is most often done with engineering type models.

28. A sensitivity analysis was applied in a study on truck replacement. There are two 2 1/2 ton truck manufacturers bidding to replace DND's current inventory. We must determine which of the two trucks is the most economical. Figure 10 shows how sensitivity analysis can alter decisions. A sensitivity analysis was performed on the

Reliability and Maintainability (R&M) values to determine how much confidence you require in the R&M projections to justify your decision.

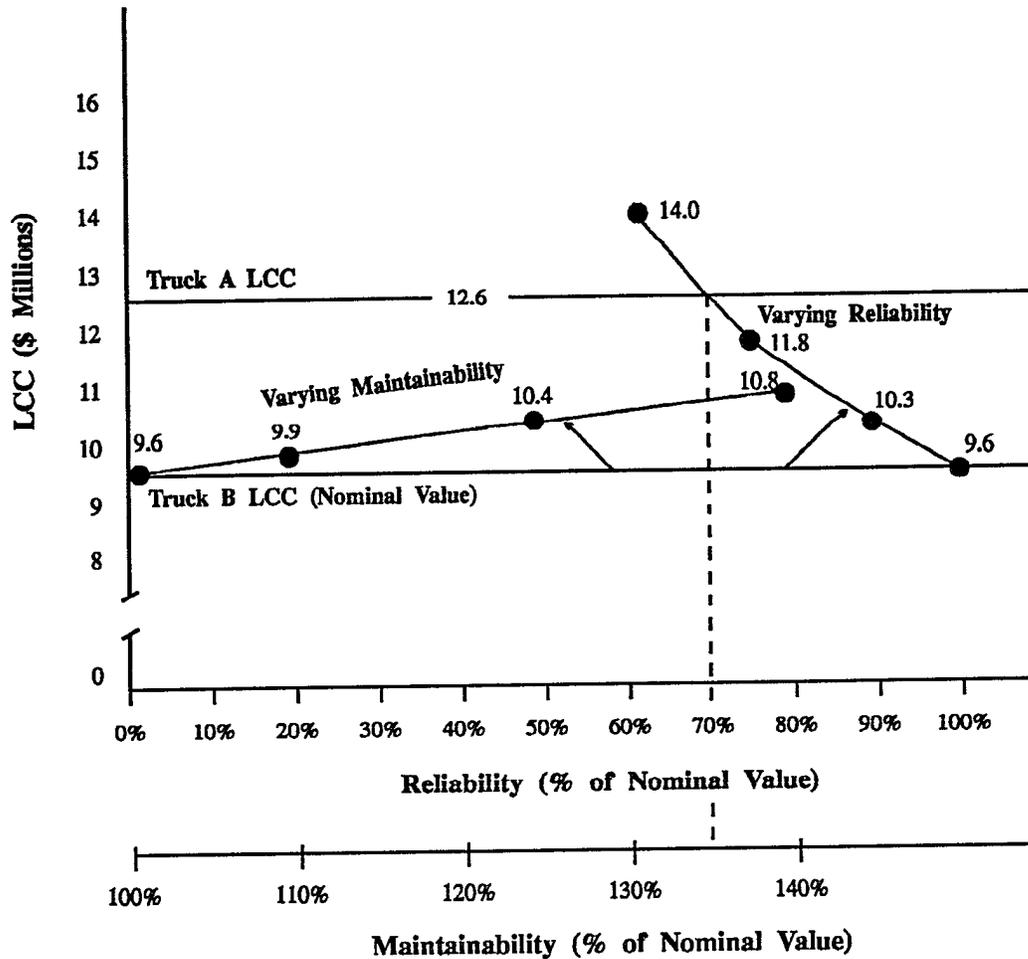


Figure 10: Sensitivity Analysis on Truck Replacement Study

29. For truck B, we use R&M values of 60%, 75% and 90% of the stated value for Reliability, and 140%, 125% and 110% for time to repair (Maintainability). We assume truck A values are fixed. The result is that the decision to favor truck B changes if Reliability is reduced to about 70% of its nominal value while the changes in Maintainability do not affect the decision. Thus we have fairly good confidence in our decision that truck B is the better choice.

## **DATA SOURCES**

30. Cost related information is scattered among numerous agencies in DND. Each functional area has developed its own method of collecting and storing its information. Each has its own goals and analysis techniques. Data gathering for LCC can be difficult but not impossible. Here is a description of the data sources available in DND.
31. The Defence Services Program Information System (DSPIS) contains information on DND resources and the cost associated with utilizing these resources. The database is divided into two parts: Capital; and Personnel, Operations and Maintenance (PO&M). The capital side contains financial information on the development, acquisition or construction of major equipments, weapon systems and facilities. The PO&M portion contains data on the programmed standard costs and the allocation of personnel, equipment and facilities, as well as estimates of their respective costs.
32. The Directorate of Costing Services (D Cost S) produces a Cost Factors Manual which contains average costs for personnel, operations and maintenance. D Cost S is also responsible for the DND Economic Model, which provides estimates of inflation rates for future expenditures.
33. The Canadian Forces Supply System (CFSS) is not an information system per se. It is an inventory control system. However, historical information related to inventory investment and parts usage can be obtained from the CFSS. With most modern weapon systems, spare parts represent a substantial proportion of the equipment's LCC.
34. There are three main Maintenance Management Information Systems (MMIS), one for each of the services: air (AMMIS), land (LOMMIS) and sea (SMMIS). Although these systems were developed separately, they have many similarities. Each was designed to collect information on all types of maintenance such as replacements, inspections, repair and overhaul, and modifications for the equipment.

## **CONCLUSION**

35. This document attempted to cover the major issues and concepts useful in the knowledge and application of LCC. While there may be many excuses for avoiding LCC,

there are also many more reasons to promote its use... if only to quantify the impact of our decisions.

## **REFERENCES**

1. MMI 1106
2. Blanchard, B.S., Design and Manage to Life Cycle Cost, M/A Press, 1978.
3. Taylor, I. and Kavanagh, K.R., Life Cycle Cost Analysis: the D Log A Perspective, D Log A Staff Note 81/12, October 1981.
4. Previous Course Notes (from the one-week Life Cycle Costing course and the one-hour course, both given at MMTC)
5. Taylor, I.W., A Life Cycle Cost Effectiveness Case Study, D Log A Research Note 94/2, November 1994.

**Canada**