Evaluation of the Developing DSN Life-Cycle Cost Standard Practice

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The DSN is developing a Life-Cycle Cost Standard Practice. This report compares the developing Practice to those of industry and the Department of Defense. Results show that the DSN uses the accepted concept of Life-Cycle Costing, tailoring the concept to DSN specific needs, but does not push the concept past the point of prevailing theory.

I. Introduction

The DSN is developing a Life-Cycle Cost (LCC) Standard Practice. At this stage of development, it is useful to compare the Practice to those of industry and the Department of Defense (DOD). Specifically, three questions are posed for study:

(1) How widely used is the Life-Cycle Cost concept?

(2) Is the DSN LCC Practice, at this stage of development, in accordance with generally accepted standards?

(3) How does the DSN LCC Practice compare with those of industry and the military; i.e., is the DSN at the state-of-the-art?

These questions are addressed in the following report.

II. Use of Life-Cycle Costing

A. Department of Defense

LCC is clearly used by the Department of Defense (DoD). An investigation of the LCC concept was made in the early 1960's by the Logistics Management Institute for the Assistant Secretary of Defense for Installations and Logistics (Ref. 1). Since that time, numerous DoD and service directives have clarified and ordered the use of Life-Cycle Cost analysis. An example is the DoD Directive 5000.28 which states:

> "Life-cycle cost estimates will be used as a basis for cost trade-off analyses when considering acquisition versus O&S costs, comparing competing prototypes or comparing current versus new systems" (Ref. 2).

Furthermore, in using LCC,

> "Life-cycle cost objectives shall be established for each acquisition and separated into cost elements within the broad categories of development, production, operation, and support. As system definition continues, the cost elements are firmed into cost goals to which the system will be designed and its cost controlled" (Ref. 3).

Thus, the Department of Defense uses Life-Cycle Costing to select a system, and then uses "design to Life-Cycle Cost elements" to control costs. One source reports that use of Life-Cycle Cost analysis has resulted in "significant cost savings," validated by the Air Force Auditor General's Office (Ref. 4).

B. Military-Related Industries

A sampling of military-related industries was conducted by the author to determine the extent to which LCC is used. Martin Marietta, Northrop, and Hughes Aircraft were contacted, and all use some form of Life-Cycle Cost analysis. One of the three has a documented standard LCC approach (Ref. 5), two have centralized LCC departments, and all three use approaches which are tailored to specific use.

Numerous industrial articles have been written on LCC analysis, and will be referenced throughout the remainder of this report. The general conclusion is that military-related industries do use some form of LCC analysis, but no single approach is standard.

C. Other Industries

Other industries use the LCC technique for purposes such as comparing alternatives:

> "In comparing alternative solutions to accomplish a particular goal, the system showing the lowest life-cycle cost will usually be the first choice, assuming the performance requirements defined by the goal are adequately met" (Ref. 6).

Industrial articles on LCC analysis were found in the following magazines and journals:

Industrialization Forum

Logistics SPECTRUM

Professional Engineer

Proceedings Annual Reliability and Maintainability Symposium

Management Accounting

The articles will be referenced, as appropriate, in the following pages. The same conclusion is reached through review of these articles; the use of the Life-Cycle Cost concept is widespread, but the specific approaches and models used are not standardized.

III. Accepted Life-Cycle Cost Standards

A. Definition of "Life-Cycle Cost"

General agreement exists on the meaning of "Life-Cycle Cost." The Department of Defense Directive 5000.28 states:

> "The Life Cycle Cost of a system is the total cost to the Government of acquisition and ownership of that system over its full life. It includes the cost of development, acquisition, operation, support, and where applicable, disposal" (Ref. 7).

Similarly, a student of the Air Force Institute of Technology writes that Life-Cycle Cost is:

> ". . . a method for evaluating and considering the total costs of ownership, including the costs of acquiring, operating, supporting, and disposing of an item, less its residual or scrap value, during its useful life" (Ref. 8).

A Martin Marietta representative states:

> "Life-Cycle Costing (LCC) is a Department of Defense (DoD) acquisition or procurement technique that considers operating, maintenance, and other costs of ownership, as well as acquisition price, in the award of contracts for hardware and related support. The object of this technique is to insure that the hardware procured will result in the lowest overall ownership cost to the Government during the life of the hardware" (Ref. 9).

A similar concept is referenced in *Professional Engineer:*

> "Life-cycle costing is an analysis of the total cost of a system, machine, device, building, and the like over its anticipated useful life" (Ref. 10).

Thus the DSN definition – Life-Cycle Cost is implementation cost, plus M&O costs over the life of the capability, plus deimplementation cost – is in accordance with the generally accepted definition.

B. Life-Cycle Cost Uses and Purposes

Although the definition of Life-Cycle Costing is standard, its uses vary with the background of those employing it. Donald Earles of Raytheon Company explains it:

> ". . . over the past ten years, Life-Cycle Costing has evolved into four things; a costing discipline, a procurement technique, an acquisition consideration, and a design trade-off tool."

The specific use depends on the user. The DSN employs LCC analysis as an acquisition consideration and a trade-off tool (Ref. 1).

C. Costing Philosophies

Just as LCC uses vary among users, costing philosophies vary with the specific application. Costs of a system may be full costs, delta costs projected from some baseline, or even variable costs. For example, a RAND weapon case study remarks:

> "It is important to note that this definition of weapon system LCCs is intended to capture only the variable costs associated with the weapon system. We make no attempt to reflect any of the "fixed" costs which are necessary for the management of the organization (e.g., HQ/USAF) which uses the system, but which are not incurred by or for the weapon" (Ref. 11).

This is the costing philosophy assumed for the DSN pathfinder LCC analysis (Ref. 12). Other companies use different approaches. Hughes Aircraft Corporation, for example, uses absolute costs, while Northrop employs absolute or delta costs, as the situation demands.

D. Project Life-Cycle Period

Another Life-Cycle Cost concept which varies in use is that of project life-cycle period. An Air Force publication notes that the LCC period may be 10-20 years for a DoD weapon system (Ref. 13). A specific cost analysis done by the U.S. Army Electronics, Communications, and Material Commands uses a 10-year period (Ref. 14). This variability is summed up in *Professional Engineer:*

> "The Life-Cycle of the system or machine must be realistically appraised. It can be defined as the expected physical life or the estimated period to obsolescence, whichever occurs first" (Ref. 10).

The variability of the life-cycle period is recognized by the DSN.

E. Life-Cycle Cost Definitions

Included in the DSN LCC Standard Practice is the requirement of definitions. Careful definitions insure fair comparisons and allow validation that no cost has been forgotten (Ref. 15). Although this is a generally accepted standard in government and industry, it is not practiced as thoroughly as is wise. Nevertheless, examples of LCC reports accompanied by careful definitions can be found. Two examples are *A Summary and Analysis of Selected Life-Cycle Costing Techniques and Models* of the Air Force Institute of Technology (Ref. 16), and *Life-Cycle Costing Emphasizing Energy Conservation, Guidelines for Investment Analysis* of ERDA (Ref. 17).

F. Cost Estimation Procedure

It is clear from even a cursory examination of the Life-Cycle Cost literature, that there are a number of cost estimating methods. Some of the titles of these methods are: per unit catalog price, cost-to-cost estimating relationships, non-cost-to-cost estimating relationships, specific analogy, expert opinion, simulation (Ref. 18), accounting, and parametric. It is the last two which express the organizational nature of cost estimating and which concern us here.

In general, the DSN uses the accounting approach, which lists all cost elements for a project over its life and, with a specific procedure, sums the costs. This method is explained:

> "The most frequently referenced of the life-cycle cost models in use today are the additive accounting models." They are useful for projects characterized by dollars and provide managerial visibility, comparison of costs, identification of specific differences in bidders' proposals, and visibility of high support costs (Ref. 19).

In comparison, the parametric approach is useful for estimating effects of learning curves, provisioning policies, management factors, repair and replacement policies, and system characteristics (Ref. 20). Only a few parametric models are sufficiently tested for DSN use.

There are numerous cost models which incorporate these methods. For example, an Air Force Institute of Technology study lists twenty such models (Ref. 21). None of these can be used as a standard cost model. As a Honeywell employee states:

> "The state-of-the-art of cost modeling, however, is not to the point where existing cost models can be used universally in whole or in part for wide varieties of applications. They are highly tailored in terms of systems treated, scope of elements covered, and categories of costs included" (Ref. 22).

Thus, there are generally accepted cost estimation procedures, one of which is used by the DSN. There are no models incorporating these methods which can be used as a standard LCC model.

G. Cost Elements

Within the accounting cost estimation method are the cost elements themselves. Again, there is no single list of detailed cost elements applicable to all projects. Examples of cost element lists are given in Tables 1 and 2 and more can be found in the literature (Refs. 13, 20, 23). At this time, however, DSN cost elements must be determined for each cost study by those familiar with the project.

H. Monetary Adjustment

Another part of Life-Cycle Costing is the monetary adjustment of projected costs. Review of the literature shows a lack of standardization here also. The Office of Management and Budget suggests the use of comparative inflation and a general discount rate of 10% (Ref. 24). A RAND study, however, uses a discount rate of 5% (Ref. 25). Northrop prefers to work solely in constant dollars and inflate only if required for bidding purposes. The Martin Marietta LCC process allows total discretion in the inflating and discounting procedures used on each cost estimation.

Thus, the monetary adjustment used in LCC estimation will depend upon the project, the intended use of the estimation, and any applicable laws.

I. Life-Cycle Cost Presentation

The form in which a LCC estimate is presented is dependent upon the project and the purpose of the estimate. The DSN pathfinder LCC analysis used a reporting format designed to reflect the specific cost elements and algorithm used in that project. Other formats can be found in the literature (Ref. 26). An example is in Table 3.

J. Standard Practice

As stated previously, the DSN is developing a Life-Cycle Cost Standard Practice. The question arises: Are LCC standard practices common in industry and government? The answer is that in reviewing sixty sources, the author encountered only four sets of documents which could be considered as standard practices. ERDA published the *Life-Cycle Costing Emphasizing Energy Conservation, Guidelines for Investment Analysis* (Ref. 17), and Martin Marietta has the *Computerized Costing Methodology* which incorporates Life-Cycle Costing (Ref. 5). The Navy has an *Economic Analysis Handbook* (Ref. 27), and the DoD has a series of documents published as guidelines for various weapon procurements (Ref. 28).

The need for standard practices, however, is well documented. A 1975 Air Force working group found that:

"At least five actions are required in order to establish an adequately effective life cycle cost analysis capability in program offices."

"1. Program offices must be provided with a source of personnel familiar with analytical techniques."

"2. These engineers and analysts must be given general guidance on how to develop, adapt and use life cycle cost models for specific applications."

"3. Program office and supporting personnel should have access to a short course in the subject of development and application of life cycle cost models and methods."

"4. Periodic life cycle cost methods workshops should be held. . . ."

"5. Finally, program office personnel should be provided with a central focus of expertise where lessons learned in each new life cycle application are integrated with existing life cycle cost models and methods . . ." (Ref. 29).

Similarly, a RAND study states:

"In order to advance the current state-of-the-art of LCC estimating, at least the following improvements" are needed:

"1. Operational consistency of LCC procedures"

"2. Better cost allocation rules"

"3. A nomenclature directory"

"4. Project LCC decision requirements"

"5. An LCC data base" (Ref. 30)

Thus, the need for standard practices is generally accepted, and some such documents already exist. The DSN, with others, is responding to this need.

IV. General Conclusions

Life-Cycle Costing is a popular technique, widely used in the military and industry. It is generally accepted that Life-Cycle Costing is a specific concept whose use should be accompanied by LCC definitions, a stated costing procedure, a stated project life-cycle period, monetary adjustment procedures suited to need, and at least a locally accepted LCC standard practice. The DSN is in accord with these generally accepted standards. The specific application of the standards is user and project dependent, as found in both the LCC literature and the DSN.

The DSN is not at the state-of-the-art of Life-Cycle Costing. The state-of-the-art is an advanced and fluctuating position including such things as economic risk analysis, performance effectiveness measurement, multiple regression analysis, and unproven parametric models. These advances are not being ignored by the DSN, but rather will be incorporated as appropriate with the DSN environment. The DSN is using an accepted tool, adapted to local needs, to reduce project costs.

References

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2. U. S. Department of Defense, *Design to Cost*, Directive No. 5000.28 (May 23, 1975), p. 4.

3. DoD Directive 5000.28, p. 3.

4. James H. Hammond, "Life-Cycle Costing for Government Procurement," *Industrialization Forum*, Vol. 5, No. 1-2, 1974, pp. 77-78.

5. Aaron N. Silver, *Computerized Costing Methodology* (Martin Marietta proprietary information), March 1976.

6. G. F. Pearson, "Life-Cycle Costing in an Energy Crises Era," *Professional Engineer*, Vol. 44, No. 7, July 1974, p. 27.

7. DoD Directive 5000.28, p. 2.

8. Lawrence E. Dover et al., *A Summary and Analysis of Selected Life-Cycle Costing Techniques and Models*, Air Force Institute of Technology Report No. SLSR 18-7 (Master's Thesis), Aug. 1974, p. 4.

9. Martin B. Goldman and Robert W. Tipton, "Accurate LCC Estimating Early in Program Development," *Proceedings of the Annual Reliability and Maintainability Symposium*, 1974, p. 256.

10. Pearson, "Life-Cycle Costing in an Energy Crisis Era," p. 26.

11. Marco R. Fiorello, *Getting "Real" Data for Life-Cycle Costing*, RAND Corporation, No. AD-A010 960, Jan. 1975, p. 6.

12. A pathfinder LCC analysis was performed for the Large Advanced Antenna Station. Results of this analysis will be published as a separate DSN Progress Report.

13. Dover, *A Summary and Analysis*, p. 2.

14. Harry Rosenberg and James H. Witt, "Effects of Test Equipment Standardization," *Proceedings of the Annual Reliability and Maintainability Symposium*, 1976, p. 287.

15. E. Posner, D. Herrman, and M. McKenzie, "LAASP Tutorial on Life-Cycle Cost" (unpublished), p. 2.

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18. Earles, "LCC – Commercial Application," p. 79.

19. Dover, *A Summary and Analysis*, p. 19.

20. Philip S. Kilpatrick and Arthur L. Jones, "Life-Cycle Cost Comparisons of Avionic System Design Alternatives," *Proceedings of the National Aerospace and Electronics Conference*, 1974, p. 515.

21. The modules can be found in: Dover, *A Summary and Analysis.*

22. Kilpatrick and Jones, "Life-Cycle Cost Comparisons," p. 514.

23. Examples of further cost element lists are found in:

Dean B. Dickinson and Lyman Sessen, "Life-Cycle Cost Procurement of Systems and Spares," *Proceedings of the Annual Reliability and Maintainability Symposium*, 1976, p. 282.

Allen Dushman, "Effects of Reliability on Life Cycle Inventory Cost," *Proceedings of the Annual Reliability and Maintainability Symposium*, 1969, p. 550.

Goldman and Tipton, "Accurate Life-Cycle Costing Early in Program Development," p. 258.

Dover, *A Summary and Analysis*, pp. 20, 25.

Earles, "LCC – Commercial Application," p. 78.

Kilpatrick and Jones, "Life-Cycle Cost Comparisons," p. 541.

Fiorello, *Getting "Real" Data*, p. 3.

24. Office of Management and Budget of the Executive Office of the President, Circular No. 9-94 Revised, March 27, 1972, p. 4.

25. Fiorello, *Getting "Real" Data*, p. 81.

26. Other reporting formats can be found in:

Fiorello, *Getting "Real" Data*, p. 13.

Marco Fiorello, *Estimating Life-Cycle Costs: A Cost Study of the A-70*, Air Force Report F-1518-PR, Feb. 1975, p. 19.

Gary White and Phillip Ostwald, "Life-Cycle Costing," *Management Accounting*, Vol. 57, No. 7, Jan. 1976, p. 40.

27. Richard S. Brown and Kenneth M. Shachmut, *Economic Analysis Handbook*, Navy Facilities Engineering Command HQ, Report No. P-442, June 1975.

28. The documents are:

U.S. Department of Defense, *DoD Life Cycle Costing Procurement Guide (Interim)*, LCC-1, July 1970.

U.S. Department of Defense, *DoD Casebook – Life Cycle Costing in Equipment Procurement*, LCC-2, July 1970.

U.S. Department of Defense, *DoD Life Cycle Costing Guide for Systems Acquisitions (Interim)*, LCC-3, Jan. 1973.

29. Dwight E. Collins, *Analysis of Available Life Cycle Cost Models and Actions Required to Increase Future Model Applications*, Joint AFSC/AFLC Commanders' Working Group, Technical Report No. ASD-TR-75-25, Dec. 1974, pp. 15-16.

30. Fiorello, *Getting "Real" Data*, p. 16.

Table 1. Life-cycle cost categories[a]

Major categories	Subcategories
Research & Development	Engineering Prototype Fabrication System Test & Evaluation Data Total Systems Management Training Producibility Engineering & Planning
Investment, Nonrecurring	Initial Production Facilities Effort Data Tooling Instruction Training Total Systems Management
Investment, Recurring	Hardware Cost Attrition Initial Spares & Repair Parts Support Equipment Auxiliary Equipment First Destination Transportation Initial Training Engineering Changes System Test & Evaluation Total Systems Management
Operating	Personnel Personnel, Replacement Training Consumption Integrated Logistics Support Depot Overhaul Transportation

[a]Source: Thomas W. Otto, Jr., *Life-Cycle Cost Model,* U.S. Army Electronics Command Report ECOM-4338, July 1975, p. 8.

Table 2. Weapon system life-cycle cost categories[a]

Major categories	Subcategories
RDT&E	Research & Development Test & Evaluation (RDT&E)
Procurement	Aircraft (Flyaway Cost) Support Equipment Training Equipment Technical Manuals SPO-Personnel Test & Evaluation (IOT&E)
Ownership	Spares: Initial, Replenishment, Engines, WRM (HDWR) Maintenance: On-Equipment Maintenance: Off-Equipment Management Personnel: System/Item Managers Training: Tech Training Operations: Crew, CMD PERS – Military and Civilian – Base Only Base Operating Support Fuel Modifications (HDWR) Testing & Evaluation (OT&E) Item Transportation (2nd DSTNTN) Munitions and Missiles – Training Personnel PCS Attrition New Facilities
Salvage & Disposal	Disposal Modifications

[a]Source: Marco R. Fiorello, *Getting "Real" Data for Life-Cycle Costing,* RAND Corporation, No. AD-A010 960, Jan. 1975, p. 7.

Table 3. LCC trade-off analysis of two competitive products for two years[a]

Cost	Vendor A	Vendor B
Product Price	$200,000	$170,000
Installation	3,000	4,000
Manning Labor (2 Yrs)	46,720	93,440
Preventive Maintenance (2 Yrs)	912	1,632
Corrective Maintenance (2 Yrs)	2,800	9,344
Power Requirements (@ 0.025/kW)	1,168	1,314
Parts & Supplies Cost (@ 1% & 2% of Product Price Respectively)	2,000	3,400
TOTAL	$256,600	$283,130

[a]Source: Gary White and Phillip Ostwald, "Life-cycle Costing," *Management Accounting,* Vol. 57, No. 7, Jan. 1976, p. 42.