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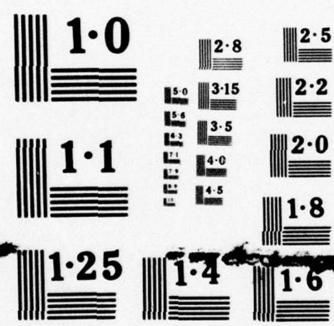

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IDA PAPER P-1292

THE FEASIBILITY OF ESTIMATING AVIONICS SUPPORT COSTS EARLY IN THE ACQUISITION CYCLE

Volume II: Appendixes

John D. Morgan
Aaron B. Fuller

September 1977

Prepared for

Office of the Director of Defense Research and Engineering

IDA

INSTITUTE FOR DEFENSE ANALYSES
COST ANALYSIS GROUP

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper reports on research to determine the feasibility of developing methods to estimate, early in the system acquisition cycle, the potential support cost inputs of alternative avionics components envisioned for Air Force and Navy fighter aircraft. Support costs are defined as those costs incurred at the organizational, intermediate (cont'd)

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Acquisitions Review Council; Cost Analysis Improvement Group; Life Cycle Costs; Independent Cost Analysis; Cost Models; Cost Estimating Relationships; Work Unit Codes; Maintenance Costs; Avionics Contractors; Visibility and Management of Support Costs; Parametric Cost Estimating.

20. continued.

and depot levels to maintain avionics equipment and the costs of avionics spares and repair parts support.

The results of the study are presented in two volumes. Volume I reviews and evaluates current methods used in industry and in the Air Force and Navy to estimate these avionics support costs; reviews and evaluates relevant industry and defense studies; reviews industry and DoD data and management systems that could provide data needed for avionics support cost estimating techniques; discusses the feasibility of developing suitable estimating techniques; and, presents recommendations on the best methods to follow in dealing with this cost estimation problem at DSARC 0, I, and II. The paper provides a comprehensive review of the DSARC process. It discusses major conceptual problems in developing estimates of future support costs for equipment still in the early development stages. Finally, the paper concludes that it is feasible and desirable to prepare these estimates for avionics support costs. The specific method to be adopted depends on the amount of resources OSD wishes to devote to this effort.

Volume II is a compilation of appendixes containing additional material to support the basic report, including summary evaluations of forty-eight key documents encountered in the literature search.

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THE FEASIBILITY OF ESTIMATING AVIONICS SUPPORT COSTS EARLY IN THE ACQUISITION CYCLE

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CONTENTS

FIGURES

TABLES

APPENDIX A

DESCRIPTIVE SUMMARIES OF PRIOR AVIONICS-RELATED RESEARCH

DESCRIPTIVE SUMMARIES OF PRIOR AVIONICS-RELATED RESEARCH

This appendix contains descriptive summaries of the major research reports and other materials that we examined and found to be particularly helpful in forming an understanding of the avionics support cost environment. Each report is summarized and presented in a standard format designed to facilitate understanding of the materials.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 1

2. TITLE: *Estimating Avionics Equipment Costs for Military Aircraft*

3. AUTHOR: INSTITUTION: DATE: James M. Daniels; J. Watson Noah Associates, Inc.; December 13, 1974.

4. PREPARED FOR: Resource Analysis Group, Systems Analysis Division, U.S.N. Chief of Naval Operations (OP-960)

5. 54 pages + 6 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, FR-206 USN.

7. BRIEF SUMMARY: The report presents a CER regression model to estimate production costs of avionics equipment early in the conceptual stage before detailed physical descriptions of the equipment are available. Ideally, the report states that regression equations with production cost as the dependent variables and performance parameters as the independent variables are desired; however, the report provides an alternative methodological approach on the strength of the assertion that the traditional approach of collecting cost and performance data for equipment previously built and then using regression analysis to develop CER's would not work for avionics equipment. The alternative approach offers a factor for production technology change derived from commercial aviation avionics historical experience.

The major reason cited why the traditional CER regression approach will not work is that the approach implicitly requires that all factors except performance parameters remain unchanged over time. The only independent variables in such an approach are performance variables. But clearly the production process for avionics equipment has changed dramatically over the past twenty years. All prior avionics CER work has failed to develop performance parameters that reflect production process changes. This report offers a way to deal with this problem of incorporating persistent production process changes into the specification of avionics production cost CERs.

The alternative methodological approach in this report is to predict cost for a known amount of performance. This is fundamentally different from the traditional CER regression approach which seeks to quantify performance variables that change over time. This report proposes to take a given level of performance permitted by today's technology and adjust the cost of this given performance level to reflect future changes in production cost and price levels. The price level issue is merely a matter of adopting an arbitrary rate of inflation based on official policy, logic, or best guess. The production cost issue is handled by estimating future changes in production technology from a trend line.

The trend line for avionics production technology is constructed by analogy with commercial aviation avionics equipment cost experience. The report asserts that "...the manufacturing technology for both military and commercial avionics is essentially the same...." If we know how manufacturing technology changes in one, we know how it changes in the other. Unlike military avionics equipment, commercial equipment does not reflect improved performance over time. Performance stays relatively constant, while price changes. Adjusting for price level changes, commercial avionics equipment has fallen in real price for given performance over time. The report assumes that this fall in real price is due to improved manufacturing technology. A trend line of falling costs of 3 percent per year was calculated (through linear regression) which reflects, according to the report, improved production technology. Arguing that production technology is the same for commercial and military avionics equipment, this trend line provides an adjustment factor to be used for imposing the effects of future production technology changes on a baseline piece of military avionics equipment. Adding the price level adjustment to the trend line-adjusted baseline cost of a piece of known avionics equipment then provides the cost of producing the known system with future manufacturing technology. Stated another way, the cost estimate developed here would be the cost to build at a particular future time a system that performs as well as an equivalent present system. Thus, what we have at this point is the cost of new systems produced with the advanced technology of the future with equipment performance held constant at the baseline level.

Given that this technique of estimating improved production technology is methodologically valid, the issue of its accuracy becomes a quantitative statistical question best handled by stochastic processes. It provides a means of explicitly entering a production technology factor into the traditional avionics CER production cost methodology of running regressions on historical data between costs and performance parameters. The performance parameters have a production technology factor present, and their predictive validity should be enhanced.

8. <u>APPLICABILITY TO DP&E-110</u>: This report suggests a way of improving traditional acquisition cost-performance parameter avionics CERs. Since acquisition cost is frequently identified as one of the most significant independent variables in O&S avionics CERs, an improved acquisition cost estimating capability reflecting production technology improvements is a valuable addition to a more complete understanding of the capabilities of regression CERs.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 2

2. TITLE: *Development of Avionic Cost/Technology Indices*

3. AUTHOR: INSTITUTION: DATE: Jack H. Namaroff and Leo Rogin; Systems Analysis and Engineering Department, Naval Air Development Center (NADC); April 1, 1972.

4. PREPARED FOR: Naval Air Systems Command (AIR-501)

5. 37 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, NADC Report No. NADC-SD-7139.

7. BRIEF SUMMARY: With the technical participation and cooperation of Information Spectrum, Incorporated (ISI), NADC developed cost and technology indices that can be applied as modifying factors to avionic acquisition cost CERs. The indices are intended to modify acquisition cost estimates by factoring in the effects of technology on cost.

Indices were developed for airborne computers and navigation systems, but the report asserts that the methodology is applicable to any avionic system.

The procedures used to develop the indices combined long range technological forecasting (engineering judgments) with cost analysis (estimates of the cost impact of technological changes). The engineering and cost-based judgments were then quantified into a trend line that depicted the expected change in costs due to technology. The trend line was smoothly extrapolated out to 1990.

Technological advances were determined to be likely in component technology, integration, packaging, reliability and maintainability.

Computer costs were broken down into hardware and software categories and separate indices were prepared for each. Under hardware, separate indices were developed for processor circuitry and memory. An example of the form that the indices take is offered by the processor circuitry index:

Year	Index
1970	1.000000
1975	.141851
1980	.018605
1985	.002767
1990	.000356 .

As can be seen, dramatic reductions in cost are forecast. The key to reading and interpreting this index is to understand that the question answered by the engineering projections was: how will today's avionics functions be handled by future technology? Thus, performance is fixed at the current level in this approach and the engineer is asked to project accomplishing these baseline performance levels with tomorrow's technology. This not only applies to processor circuitry, but to all the indices presented in the report.

The navigation costs were broken down into three functional areas: sensor, electronics, and data processing. Separate indices were prepared for each functional area.

8. <u>APPLICABILITY TO DP&E-110</u>: This report suggests a way of improving acquisition cost regression CERs by explicitly incorporating the effects of technology change on cost. Since acquisition cost is frequently identified as one of the most significant independent variables in O&S avionics CERs, an improved acquisition cost estimating capability reflecting avionics technology improvements is a useful addition to a more complete understanding of the capabilities of regression cost estimating.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 3

2. TITLE: *DoD Actions to Control Avionics Life-Cycle Costs*

3. AUTHOR: INSTITUTION: DATE: J. F. Digby; RAND; May, 1973.

4. PREPARED FOR: Defense Advanced Research Projects Agency, Tactical Technology Office

5. 43 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, WN-8234-ARPA (advance copy).

7. BRIEF SUMMARY: This paper is a policy "think piece" that defines policy options for DDR&E consideration when approaching the issue of how to "control" avionics life cycle costs. It is a survey of the existing literature combined with some oral interviews and all woven together by speculative assessments from the author.

Relying on research conducted by David Dreyfuss (RAND WN-8235-ARPA, *A Survey of Costing Methods in the Avionics Industry,* May, 1973) and Fred S. Timson (RAND WN-8236-ARPA, *Practicality of Life-Cycle Cost Models as Aids to Acquisition Decisionmaking: Confidence in Estimates,* May, 1973) the author concludes that there are (pre-1974) no adequate methods for estimating LCC, or even initial cost, as a function of mission performance for avionics equipment. Instead, the author distills the Dreyfuss and Timson papers into a conclusion that contractor avionics cost estimates are based on preliminary engineering designs which constitute the framework for a bottoms-up cost estimate. This essentially involves accounting for each of the parts in each of the processes required in manufacturing the equipment, or else a variation of this which uses industrial engineering methods to extrapolate from past designs, possibly using regressions of plots against physical or other detailed properties.

The remainder of the paper discusses the importance of controlling avionics LCC (because the absolute dollar magnitude is large), fourteen policy options for controlling avionics LCC, the AFLC LCC model, data systems to feed the AFLC model, and incentives to stimulate low LCC designs.

The apparent emphasis on the AFLC LCC model is due to the author's opinion that it is representative of the best of the "accounting" approaches to LCC. By accounting approach he means equations that might be made by a cost accountant, in which most of the terms are simple linear terms which multiply the number of times that something has to be done by the number of man hours that it takes to do it and then by the cost per man hour.

Timson lists 66 of the terms that comprise the AFLC equations and identifies 42 of them as the responsibility of the contractor and 24 of them as beyond contractor responsibility. Finally, he concludes that estimates of these inputs are so difficult that the resulting ranges of error are too large to permit the estimates to be useful.

8. <u>APPLICABILITY TO DP&E-110</u>: The report surveys the state-of-the-art of avionics cost estimating by contractors in 1973. The conclusion is that performance sensitive cost estimating (acquisition and LCC) models do not exist. The contractors use engineering based bottoms-up approaches. The Air Force AFLC LCC model utilizes many of the inputs from the bottoms-up approach produced at the contractor level.

Based on the DP&E-110 team understanding of the state-of-the-art in 1977, little has changed since 1973.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 4

2. TITLE: *Cost Analysis of Avionics Equipment*

3. AUTHOR: INSTITUTION: DATE: E. N. Dodson, S. F. Kornish, R. R. Lieberman and W. E. Waller; General Research Corporation (GRC); February, 1974.

4. PREPARED FOR: Air Force Avionics Laboratory (AFAL)

5. 124 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AFAL-TR-73-441, Vol. I.

7. BRIEF SUMMARY: This is volume one of a three volume study that develops avionics regression CERs. Volume two is the data base which generated the coefficients in the regression equations, and volume three is a user's manual for the computer programs which processed the data to generate the regression coefficients.

Four types of equipment were investigated: inertial measuring units, avionics computers, doppler navigators, and fire control radars.

The dependent variables in the procurement regression CERs are costs of the equipment. Thus for fire control radars the procurement regression CER is

$$\ln \text{Cost} = 1.319 + 1.15 \ln R + 0.872X_1 + 0.656X_2 + 0.679X_3$$

where:

$\ln$ = the symbol for natural logarithms

Cost = first unit recurring cost in FY 74 $\$10^3$

R = single pulse detection range

X_1, X_2, X_3 = dummy variables

$R^2 = .91$

$F = 53.37$

Coefficients significant at .01 level.

Logistic support CERs were also developed, but only those for LRU maintenance were regressions. The remaining O&S costs were estimated by factors, usually as a percentage of equipment investment. The maintenance regression CERs used procurement cost of the equipment as the major (usually only) independent variable. Thus, for general avionics maintenance applicable to all classes of avionics equipment, the equation is

$$\mathit{ln}\text{Cost} = -1.62 + 0.86\ \mathit{ln}Y_1$$

where:

ln = natural logarithm

Cost = annual maintenance cost per unit in 1974 $\$10^3$

X_1 = Bombing Navigation Subsystem type cumulative average cost at 1,000 units in $\$10^3$

R^2 = .96

F = 232.3

t = 15.24.

An additional feature of this paper is that production cost technology indices and performance technology indices are explicilty incorporated into the R&D regression CERs. Although the effects do not carry over into procurement or O&S CERs, the application is an instance where regression CERs (for R&D) are modified by technology factors explicitly.

8. <u>APPLICABILITY TO DP&E-110</u>: This paper is primarily an example of the difficulties of constructing specific equipment regression CERs, whether for procurement, R&D, or O&S costs. Because of limitations, available data were regressed and the best fit coefficients selected as the best equation forms. Discussions of technology, data, and actual CER regressions are useful introductions of fundamental issues in regression CER development, but the results implemented here offer no resolutions of these issues.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 5

2. TITLE: *Aircraft Operating and Support Cost Impacts of Support Concepts and Design Characteristics*

3. AUTHOR: INSTITUTION: DATE: K. E. Marks; Naval Aviation Integrated Logistic Support Center (NAILSC); March 17, 1976.

4. PREPARED FOR: NAVAIR (AIR-4013)

5. 54 pages + 80 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, NAILSC Report No. 02-12-1.

7. BRIEF SUMMARY: This report described the initial planning for development of a proposed aircraft O&S model that would go to detailed equipment levels in its O&S cost displays (four or five-digit Work Unit Code level). However, the report declares that because WUCs are not standardized below the two-digit level, a different coding system is needed for the cost model project. The intention is to have a single code that identifies similar parts regardless of the aircraft on which they are used. NAILSC has already developed such a coding system appropriate for Navy aircraft.

The model will accept input data for reliability, maintainability, and spares costs for each NAILSC-coded equipment group. These data will consist of one or more stochastic variable(s). The use of stochastic variables is seen as a means of using values that realistically incorporate the individual characteristics of the individual components in each group.

The reliability and maintainability of the NAILSC-coded equipment groups are combined with policy variables to relate logistic support resource quantities and their costs to the effectiveness of the support system. This is designed to permit the model to compute not only the amount that would be spent for O&S, but also the impact of this expenditure on the operational effectiveness of the weapon system. Policy variables are divided into two classes, support and operations. Support policy variables include scheduled maintenance tasks and intervals, level of repair, skill levels, types of support equipment available, supply pipeline lengths, stock levels, requisition priority, and extent of cannibalization. Operations policy variables include number of operating aircraft, number of aircraft per squadron, squadron location, planned utilization, sortie length, number of landings per sortie. These operations policy variables are essentially contained in the Weapon System Planning Document.

Because the input variables are stochastic (probability statements), the model is designed to produce probability output. The support system, according to the report, affects an aircraft in two ways--through the ability of the aircraft to initiate a mission when needed; and through the ability of the aircraft to complete its mission. These two factors are called availability and dependability. Availability for a specific mission can be mathematically stated as the probability that an aircraft can begin its mission when called upon; dependability for a given mission is the conditional probability that an aircraft completes the mission given that it began the mission. A single probability parameter can be produced from these values that represents the overall effectiveness of the support system for producing availability and dependability.

The cost model will accept a desired value for probability of mission success as an input. Then the O&S costs associated with the given success can be generated.

This model can be used in the early development stages of an aircraft, including the conceptual state, by employing analogy to a similar aircraft.

8. <u>APPLICABILITY TO DP&E-110</u>: This is an ambitious project that seeks a bottoms-up approach that will be sensitive to aircraft design as well as operations and support policies. The explicit rejection of regression CERs is curious, because the model task order specifies the purpose of the AIRTASK as a standardized, quick response, semi-automated parametric cost estimating capability for logistic support assets. Since the model is still under development, we can only await its final form to assess its characteristics. A major difficulty may be the cross-walk from WUC to the NAILSC code into the model.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 6

2. TITLE: *Life Cycle Cost Analysis Guide*

3. AUTHOR: INSTITUTION: DATE: Lavern J. Menker; Aeronautical Systems Division, Comptroller; AFSC; November, 1975.

4. PREPARED FOR: Joint AFSC/AFLC Commander's Working Group Life Cycle Cost

5. 88 pages + 54 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number of code).

7. BRIEF SUMMARY: The LCC guide was prepared under the authority of AFR 800-11, which states that the Air Force will determine and consider, to the maximum possible extent, LCC in various decisions associated with the development, acquisition, and modification of defense systems. It is directed particularly to program managers and operations research and other analysts.

Chapter 1 discusses LCC reduction opportunities, including research and development actions, acquisition policies, and design actions.

Chapter 2 provides an overview of the system acquisition process including the stages of DSARC, although DSARC 0 is not explicitly discussed.

Chapter 3 discusses in substantial detail the phases of the institutional applications of the policies summarized in Chapter 2--the validation phase program events and LCC-related activities, including such specific institutional procedures as the program management plan (PMP), the source selection decision, and the independent cost analysis (ICA).

Chapter 4 examines specific LCC analysis task descriptions to provide even more details as to how the institutional applications of the policies discussed in Chapters 2 and 3 interface with and require LCC analyses.

Chapter 5 discusses methodological approaches and terminology in LCC analyses.

The Appendixes are valuable discussions of technical specifics relating to LCC, especially Appendix C which provides descriptions of representative LCC models.

8. <u>APPLICABILITY TO DP&E-110</u>: This document is a primary research item that provides important conceptual and factual information about LCC in the Air Force.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 7

2. <u>TITLE</u>: *Life Cycle Cost, Findings and Recommendations*

3. <u>AUTHOR: INSTITUTION: DATE</u>: Don Earles and Jug Starr; Ad Hoc Committee of the National Security Industrial Association; April 1976.

4. <u>PREPARED FOR</u>: Assistant Secretary of Defense, I&L

5. 40 pages

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE</u>: Unclassified, (no identifying number or code).

7. <u>BRIEF SUMMARY</u>: The paper presents a review of life cycle costing procedures performed by a sophisticated committee of the NSIA. Don Earles of Raytheon chaired the committee which was broken down into five subcommittees for aircraft, ships, vehicles, weaponry, and electronics. Committee members included Fred Carlson of Boeing, Al Frager, then of McDonnell Douglas, Dick Waina of Hughes, H. I. Jug Starr of Hughes, and Harry Lingo of Vought, among others.

The committee was formed in November 1974, and met seven times. This document is the result of its last and final meeting. In March 1975, the committee met with Russ Shorey of OSD. Based on his desires to see the NSIA members polled on life cycle costs, mailings were made to the membership soliciting inputs concerning the current status of LCC. Don Earles and Jug Starr prepared this report.

The paper offers several summary sets of positions concerning LCC too numerous to summarize in their entirety. The flavor of the material is suggested by this list of industry findings concerning industry experience with DODD 5000.28, the LCC directive:

A. Life cycle costs are not currently an identifiable consideration of the affordability studies typically conducted by the procuring activity.

B. During the past two years, life cycle cost considerations have appeared in some form or other in most acquisitions. Generally, it (LCC) is as a gross consideration of the procurement. In no case known to the committee were specific cost objectives or requirements for the elements of life cycle cost established.

C. The committee identified some one-of-a-kind systems where "design to" acquisition costs were established. In these cases, acquisition costs included all contractor-incurred costs up to acceptance testing. One case specified both design to unit production and installation costs. One case placed a "design-to" cost on an equipment within a system. One case required a "design-to" crew size. The committee did not find any case where the other elements (development, outfitting, operation and support) of a systems life cycle cost were being used as "design-to" cost goals.

D. The committee identified cases where life cycle costs were supposed to be a major consideration in source selection, but there was a skepticism of their true consideration. This skepticism was based on the government-furnished models and how they were used, the lack of significant questions during proposal evaluations, and isolated cases where performance and/or lower unit cost overruled life cycle cost considerations.

E. Life cycle cost estimates have been required in most RFPs issued in the last two years, especially during the past year. Some of the RFPs ask for an estimate to be included in the proposal, others only ask that the proposer explain how he will do the estimate, still others ask that data be forwarded to the customer in a precise format such that he can use his own model(s) to estimate the life cycle cost of a proposed system.

F. Life cycle costs currently being requested are generally for one time estimates. Rarely is LCC specified as a recurring activity to be scheduled in the program plan. Typically, we saw a general statement to the effect that life cycle costs will be considered in the analysis of proposed design changes.

G. The committee was unaware of any preplanned life cycle cost goals used to control initial outfitting cost. There were many cases where ORLA or LOR analysis had been conducted on programs, but predominately the results of the analysis were not followed. Cases exist where ORLA was initially planned on programs and then dropped due to a shortage of funding. We noticed that cost limits were frequently applied to provisioning, however these limits were not derived from preplanned life cycle cost goals but rather from annual budget limitations.

H. There has been an increasing number of programs where operating and support cost trades have been made between the cost of organic support and contractor support and/or warranties. However, these trades were not planned as part of the overall life cycle cost management programs, but as afterthoughts.

I. In spite of procedures to the contrary, the impact of requested changes resulting from operational use are not evaluated from a life cycle cost standpoint.

8. <u>APPLICABILITY TO DP&E-110</u>: This brief paper presents industry perspectives of LCC as of mid-1976. It is a valuable source for assessing the industry approach to taking LCC seriously.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 8

2. TITLE: *Opportunities for R&D Action to Reduce Acquisition and Support Costs of Tactical Aircraft (Vol. I, Summary)*

3. AUTHOR: INSTITUTION: DATE: Donald M. Dix and John Metzko; IDA; November, 1975.

4. PREPARED FOR: Defense Advanced Research Projects Agency, Task T-123

5. 67 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, IDA Paper P-1141.

7. BRIEF SUMMARY: This study relates capabilities of tactical aircraft to their acquisition and support costs, and identifies opportunities for R&D action which appear to offer substantial cost-reduction potential with emphasis on support costs.

The analysis indicates that the potential impact of R&D actions at the level of alternative implementation policies is limited. Although opportunities may exist which provide a high return on investment, their overall impact is limited since they generally do not affect tradeoffs in force capability parameters.

One area of possibly high potential impact is in determining the relationship between indirect support costs and force capability as a means to reduce any substantial fixed costs.

8. APPLICABILITY TO DP&E-110: The paper provides good general discussions of O&S cost issues, and particularly of the relationship between costs and aircraft capabilities. In the course of the development of these discussions, several essential terms are defined, and institutional evaluations are made of the acquisition processes, including the DSARC stages.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 9

2. TITLE: *Studies in Resource Estimation for Development Programs*

3. AUTHOR: INSTITUTION: DATE: E. N. Dodson, J. J. McCord, and C. A. Graver; General Research Corporation; May, 1969.

4. PREPARED FOR: Office of Assistant Secretary of Defense, Systems Analysis

5. 224 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, CR-0365-1.

7. BRIEF SUMMARY: The paper documents research efforts to improve methods of estimating the resources required to carry out engineering development projects, with missiles being the specific hardware used in the analysis.

The approach is statistical in that performance, cost, and schedule data from past missile development projects are required to test and calibrate a sequence of models. The first model measures state of the art (SOA) advance implied by performance characteristics of the missile system. The second model relates measured advances in SOA to the resources required to achieve them.

The study also makes technical contributions to applied mathematical procedures, including the "fitting" of multidimensional surfaces.

8. APPLICABILITY TO DP&E-110: This paper is a sophisticated technical approach to introducing state of the art (SOA) variables into cost and resource estimates. It is related to work that attempts to introduce technological advance parameters and constants into cost equations. It is not directly useful to the task at hand, but does provide useful background and insights into the general field of cost estimating techniques.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 10

2. TITLE: *Electronics-X: A Study of Military Electronics with Particular Reference to Cost and Reliability (Volume 2, complete report)*

3. AUTHOR: INSTITUTION: DATE: Howard P. Gates, et al; IDA; January, 1974.

4. PREPARED FOR: Defense Advanced Research Projects Agency

5. 429 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, IDA Report R-195.

7. BRIEF SUMMARY: This report identifies DoD and industrial policies, procedures, and practices in the development, production, and operational support that influence military electronics cost and reliability. The document is too extensive to present a terse summary here.

8. APPLICABILITY TO DP&E-110: This is a primary research document that provides a comprehensive background in military electronics into the early 1970s. Background in this report includes speculative assessments of the difficulties in costing, tracking, and even defining military electronics systems; original data compilations and processing and analyses; institutional descriptions of DoD and commercial military electronics acquisition and support. This was a valuable first cut at a comprehensive view of the military electronics world.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 11

2. <u>TITLE</u>: *Improved Life Cycle Cost Estimating*

3. <u>AUTHOR: INSTITUTION: DATE</u>: C. E. Earnhart; McDonnell Aircraft Company; December, 1976.

4. PREPARED FOR: McDonnell Aircraft Company

5. 25 pages plus 25 pages of appendixes

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE</u>: Unclassified, MDC A4563.

7. <u>BRIEF SUMMARY</u>: This document reports on McDonnell Aircraft Company research using Navy data to develop algebraic and regression equations that estimate aircraft support costs. The equations are described as providing sensitivities to key aircraft design parameters of reliability, maintainability, and unit production cost.

8. <u>APPLICABILITY TO DP&E-110</u>: The equations discussed in this report are the Navy "top-level" operating and support cost equations utilized for the F-18 DSARC II presentation.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 12

2. TITLE: *Supplemental Life Cycle Costing Program Management Guidance*

3. AUTHOR: INSTITUTION: DATE: John D. S. Gibson; Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost; March, 1975.

4. PREPARED FOR: AFSC/AFLC Joint Commanders

5. 24 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: This guidance is intended for Air Force program managers. Sections I and II describe the nature and scope of LCC activities, including the effects that design decisions have on LCC. Section III examines the management of program engineering to incorporate LCC consciousness. Section IV provides a catalogue of design and program issues which can affect LCC. Finally, Section V summarizes the responsibilities of program managers for LCC and discusses sources of assistance in applying LCC concepts.

8. APPLICABILITY TO DP&E-110: The guidance establishes Air Force program managers' LCC responsibilities, including the types of qualitative perspectives they should try to apply to the implementation of LCC programs.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 13

2. <u>TITLE</u>: *Digital Avionics Information System Preliminary Life-Cycle Cost Analysis*

3. <u>AUTHOR: INSTITUTION: DATE</u>: Gary K. Pruitt, et al.; ARINC Research Corporation; September 1975.

4. <u>PREPARED FOR</u>: Air Force Human Resources Laboratory

5. 33 pages + 30 pages of appendixes

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE</u>: Unclassified, AD-A017-166.

7. <u>BRIEF SUMMARY</u>: A mathematical model was developed and exercised to evaluate the LCC of avionics developed according to the Digital Avionics Information System (DAIS) approach. The objective was to provide an initial estimate of the costs and cost savings associated with the DAIS concept. The AFLC LSC model was used as the basic support cost model.

DAIS is intended to provide the capabilities to

(1) meet new mission requirements primarily by means of software rather than hardware changes;

(2) increase mission reliability through the use of redundancy and fault-tolerant systems;

(3) add or change sensors without reviewing the aircraft;

(4) improve commonality between aircraft types with a reduction in logistic requirements;

(5) maximize use of modular design in both hardware and software.

The LSC model was run for four different aircraft types for both conventional and DAIS configurations. Some of the prominent LSC results indicate that cost effects can be witnessed in the areas of--

(1) <u>Spares</u>. A module-removal maintenance concept greatly reduces the cost of base and pipeline spares from that associated with the removal of "black boxes" (Line Replaceable Units).

(2) On-Equipment Maintenance. The projected built-in test capabilities of the DAIS system will reduce the costs associated with on-equipment maintenance by reducing the man-hours required for troubleshooting the system for corrective or preventive maintenance.

(3) Off-Equipment Maintenance. A disposable-module maintenance philosophy, coupled with a comprehensive built-in test capability, will minimize the maintenance man-hours for off-equipment maintenance.

(4) Support Equipment. The costs associated with the acquisition and operation of the support equipment required to maintain a system of avionics should be reduced for a DAIS-configured aircraft system. This cost advantage would increase with the number of aircraft types in which DAIS was incorporated because the quantity of support equipments required would be reduced. The actual requirements for support equipment depend on the maintenance philosophy, but a minimization of different module types will minimize support-equipment requirements for either the module-removal or black-box-removal approach.

(5) The fundamental concept of avionics commonality. Provides substantial cost reductions throughout the Air Force by centralizing both direct and indirect support of operational units. Uniformity of avionics hardware would permit minimizing the number of maintenance, supply, technical support, and management facilities required to support the aircraft, and all phases of system support would be streamlined.

8. **APPLICABILITY TO DP&E-110**: DAIS provides an application of the LSC model to a proposed avionics system improvement, demonstrating some of the model's sensitivities and capabilities.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 14

2. TITLE: *Incentives for Cost Efficiency in the Design and Acquisition of Avionic Systems*

3. AUTHOR: INSTITUTION: DATE: B. D. Bradley; RAND; May, 1973.

4. PREPARED FOR: Advanced Research Projects Agency (ARPA)

5. 9 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, RAND WN-8239-ARPA.

7. BRIEF SUMMARY: This brief paper reviews the major problems encountered during OSD attempts to control avionics LCC. At the departmental level of the services there are no strong incentives to follow through on LCC programs. More weight is given to the achievement of performance and schedule goals and to RDT&E and procurement funds than to LCC cost goals.

At the system program management level, the program director has little responsibility for O&S goals. Career progression structures for the program director are built on criteria other than cost minimization.

More detailed discussions of these incentive problems are offered in the paper.

8. APPLICABILITY TO DP&E-110: These institutional elements of the system as it existed in 1973 are still with us in varying degrees. If incentives are to be built into the system, then O&S cost visibility throughout the DSARC process is critical. The capability of OSD to impose discipline on these institutions which will enforce LCC goals is directly related to the OSD technical apparatus for independently checking O&S cost estimates. Thus, the incentives discussion in this short paper is in fact a discussion of the state of the world to which the DP&E-110 task is a direct response.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 15

2. TITLE: *The Use of Models in Support of Policies to Control Avionics Life Cycle Cost*

3. AUTHOR: INSTITUTION: DATE: James D. Steel; RAND; May, 1973.

4. PREPARED FOR: Advanced Research Projects Agency (ARPA)

5. 8 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, RAND WM-8236-ARPA.

7. BRIEF SUMMARY: This short paper is a conceptual discussion of the types of decisions required when implementing a varied array of avionics LCC policies. There are fourteen different policies and they all will not be listed here. As an example of the policies, Policy B states that in order to control avionics LCC, "...projections of avionics LCC shall be made prior to acquisition and used as one criterion for contract award. The Services shall develop parametric costs which relate total LCC or amortized LCC to mission performance."

The three decision types are:

(1) Trade-offs, such as performance versus support and design versus support;

(2) Warranty and budget estimating;

(3) Contract development, source selection, system development completion.

Trade-off decisions require models that are capable of considering two or more levels of performance or operational capability, or are capable of considering two or more design alternatives having similar performance characteristics. The equations of the model should provide total costs of a piece of avionics equipment as functions of performance parameters or design parameters. The estimated costs are significant in their relative magnitude.

For the warranty and budget estimating decisions, the LCC model should be structured to predict a resource requirement to accomplish a given set of tasks. The model must be temporally sensitive, able to calculate costs by category per unit of time to provide a time distribution of resource requirements.

Contract development, source selection, system development completion decisions require models whose outputs will be used as inputs for establishing incentives and penalties, support cost evaluations, and development test result evaluation. Absolute value estimates are critical here.

8. APPLICABILITY TO DP&E-110: The conceptual discussion of the types of decisions required in approaching avionics life cycle costing is directly relevant to the conceptual design of an avionics component O&S (maintenance and spares) cost model as required in the task order.

1. DP&E RESEARCH MATERIAL CONTROL NUMBER: 16

2. TITLE: *Life Cycle Cost Procurement Guide*

3. AUTHOR: INSTITUTION: DATE: John E. Kernan, Jr., and Lavern J. Menker; Aeronautical Systems Division, Comptroller; AFSC; July 1976.

4. PREPARED FOR: Joint AFSC/AFLC Commanders Working Group on Life Cycle Cost

5. 140 pages + 40 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: The document discusses the application of LCC procurement techniques for systems, subsystems, and equipments. It is directed to program managers and procurement personnel.

Chapter 1 presents the current status of LCC procurement policy in the Air Force, including definitions of terms and the role of the contracting officer.

Chapter 2 presents an overview of system acquisition including a discussion of the key elements of the DSARC process.

Chapter 3 focuses on LCC acquisition strategies, including the utilization of LCC estimates, cost data reporting, and cost sensitivity analysis.

Chapter 4 examines in detail LCC procurement techniques including those used for source selection criteria, pre-award testing, trade studies, and reliability and maintainability acceptance criteria.

Chapter 5 relates R&M programs to LCC procurement.

Chapter 6 relates program documentation to LCC procurement, and includes discussions of ROC, DCP, PMD, Source Selection Plan, and other documentation specifics.

Chapter 7 gives a detailed view of the source selection process including the role of LCC.

Chapter 8 presents contract implementation institutions.

Chapter 9 is a lesson-learned discussion extracting pertinet perspectives acquired from reviews of prior procurement programs.

8. APPLICABILITY TO DP&E-110: This document is a critical resource for understanding LCC and its official role in procurement in the Air Force today.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 17

2. TITLE: *Activities, Accomplishments and Observations of the Joint AFSC/AFLC Commanders Working Group on Life Cycle Cost 1973-1976*

3. AUTHOR: INSTITUTION: DATE: John D. S. Gibson; Aeronautical Systems Division; November 1976.

4. PREPARED FOR: AFSC/AFLC Joint Commanders' Working Group

5. 22 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: This paper is similar in nature to an after-action report which assesses lessons learned in the course of a project. It provides evaluations of the entire spectrum of Air Force Life Cycle cost programs within AFSC and AFLC. Several qualitative observations concerning difficulties or misconceptions encountered when assessing life cycle costing are emphasized. In effect, it provides one set of opinions, based on three years of work, concerning the entire framework of life cycle costing in the Air Force Systems and Logistics Commands.

One important opinion is that a universally accepted life cycle cost model is not the solution to achieving LCC implementation in the Air Force. "This is not and never was true." There are many different types of LCC models that are uniquely suited to specific purposes. Diversity is necessary.

Most LCC models have one common deficiency--they are not design sensitive. This greatly reduces their value for design trade-off studies. Because almost every device has a unique set of parameters, it is strongly suggested that different LCC models may be required for each device if the models are to be design sensitive.

8. <u>APPLICABILITY TO DP&E-110:</u> This overview of three years of research into AF LCC models and their applications aids in understanding the formal and informal environments within which the avionics component O&S costing will be introduced.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 18

2. TITLE: *Maintainability/Reliability Impact on System Support Costs*

3. AUTHOR: INSTITUTION: DATE: W. L. Johnson and R. E. Reel; Boeing Aerospace Company; December 1973.

4. PREPARED FOR: USAF Flight Dynamics Laboratory

5. 90 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AFFDL-TR-73-152.

7. BRIEF SUMMARY: This report provides a methodology for estimating LCC, primarily during the operational phase. In addition, it examines quantified savings that can be determined during conceptual phase work.

The report begins with a figure which shows the percentage of total ownership costs committed during conceptual planning, design, development, acquisitions, and operations for major Air Force programs. Reading from the figure, 70 percent of LCCs are committed to their final volumes during the conceptual stage.

Using experience data, factors and trends discussed in the report, example cost analyses were performed on three aircraft--F-111, F-4, A-7D. A cross-section of 66-1 data made up the data base. The data were evaluated to determine where high support costs were being generated. Equating these high cost generators to known state-of-the-art advancements, improvement objectives were established and applied to cost factors from AFM 173-10 to derive overall cost reductions per squadron per year for each aircraft.

As an example of the analytical content, we can look at the report's treatment of replenishment spares. Rep spares costs are identified as a function of component reliability.

Decreases in failure frequencies of parts are assumed to have a proportional effect on rep spares cost.

8. <u>APPLICABILITY TO DP&E-110</u>: The applicability to DP&E-110 is as a background piece discussing reliability-maintainability in detail, especially as they relate to LCC.

1. DP&E RESEARCH MATERIAL CONTROL NUMBER: 19

2. TITLE: *Cost Effective Integrated Logistic Support, A Case Study and Evaluation*

3. AUTHOR: INSTITUTION: DATE: James R. Grubb; Defense Systems Management School; November, 1974.

4. PREPARED FOR: LTC Bernard Demers, Defense Systems Management School, Program Management Course, Class 74-2

5. 47 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: The study examines specific GFE acquisition programs on ILS. The responsibilities of the Navy APML (Assistant Program Manager, Logistics) are reviewed.

The specific GFE examined is an inertial navigation system (C-INS).

Included in the background discussion is a brief description of the manner in which OSIP (Operational and Safety Improvement Program) and ECPs are processed through NAVAIR.

8. APPLICABILITY TO DP&E-110: The background discussions assist in forming the institutional understanding of Navy avionics component procurement and costing procedures.

1. DP&E RESEARCH MATERIAL CONTROL NUMBER: 20

2. TITLE: *Fire Control Radar and Airborne Computer Cost Prediction Based on Technical Parameters*

3. AUTHOR: INSTITUTION: DATE: Major R. W. Grimm; USAF Avionics Laboratory; September 1973.

4. PREPARED FOR: Avionics Laboratory

5. 22 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: This paper presents a series of alternative regression equations which predict acquisition and development costs for airborne digital computers and fire control radars. Some of the equations include explicit measures of technological change based on approaches proposed by General Research Corporation (the "direct" method) and NADC (the "baseline" method). These two approaches measure state-of-the-art (SOA) and SOA-advance (SOAA). More on these techniques can be found in *Development of Avionic Cost/Technology Indices*, NADC, 1972 (prior research paper #2 in this series of summaries); and *Studies in Resource Estimation for Development Programs*, GRC, 1969 (prior research paper #9).

One interesting result of this work is that the technological change variables were found to be insignificant (in the statistical sense) for the prediction of airborne computer acquisition costs.

The radar acquisition cost regression without SOA and SOAA variables is

$$\text{LOG COST} = 16.67710+3.01762(\text{LOG}(X_1)) + 3.16536\text{LOG}(X_2) + 0.43619\text{LOG}(X_3) + 0.39914\text{LOG}(X_4).$$

X_1 = antenna gain
X_2 = receiver sensitivity

X_3 = input volt-amps
X_4 = pulse-width band-width product

The t-tests provide statistical significance at the .025 level, the coefficient of determination is .7075, and the standard error estimate is .6452. Running the equation for 29 actual radars for which production cost is known yielded these results: the average error was 46.7 percent, with most errors lying between 52 percent and 199 percent of actual cost. The paper states that the current state of the art in estimating avionics production costs is to underestimate by 150 percent, which translates into a relative error (actual-predicted/actual) of 60 percent. Thus, the above CER reduces average error in predicting cost from 60 percent to 47 percent, and changes the estimating bias from underestimating to unbiased estimating (unbiased because the 47 percent average errors are both over and under estimates).

8. <u>APPLICABILITY TO DP&E-110</u>: This paper is a forerunner of the Dodson-Kornish work on inertial measurement units, doppler radars, and forward-looking infared sets. It provides some good examples of hands-on regression work for avionics, although it is confined to production and development cost and does not touch support costs explicitly. Implicitly, the independent variables determining production and development costs may be useful in pursuing linkages between design parameters and support costs.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 21

2. TITLE: *Getting Real Data for Life-Cycle Costing*

3. AUTHOR: INSTITUTION: DATE: Marco R. Fiorello; RAND; January 1975.

4. PREPARED FOR: Presentation at the IEEE 1974 Electronics and Aerospace Systems Conference

5. 16 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, RAND P-5345.

7. BRIEF SUMMARY: The discussion focuses on the identification, collection, and utilization of historical Air Force data for estimates of weapon system LCC. It is conceptually oriented and offers speculative assessments of the difficulties of gathering "meaningful" LCC data in the Air Force.

The study findings note that:

(1) There is no one Air Force (or any other Service) data system which provides weapon system LCC;

(2) Nomenclature differences among the same equipments on different aircraft complicate the data gathering process;

(3) About 70 percent of ownership costs are known explicitly.

8. APPLICABILITY TO DP&E-110: This brief paper provides a useful speculative introduction to data system characteristics in the Air Force that affect LCC data gathering quality and usefulness.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 22

2. TITLE: *Models and Methodology for Life Cycle Cost and Test and Evaluation Analysis*

3. AUTHOR: INSTITUTION: DATE: Richard H. Anderson, et al.; AFSC (Kirtland AFB) Office of the Assistant for Study Support (OAS); July 1973.

4. PREPARED FOR: OAS - Kirtland AFB

5. 111 pages + 50 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, OAS-TR-73-6.

7. BRIEF SUMMARY: This report presents two basic approaches to modeling done at Kirtland AFB in an attempt to better estimate LCC during the test and evaluation phase of weapon system acquisition.

The initial model is called MCSP (Mission Completion Success Probability). It is a probability model that relates mission success to subsystems. Using A-7D data, the model is exercised to demonstrate the ranking of subsystems according to abort-causing failures. Reliability optimization is not part of the MCSP approach; however, combining MCSP with reliability optimization produces the second kind of model, the DSPC (Designing to System Performance/Cost).

DSPC systematically identifies subsystem options which provide the highest system performance at a prescribed level of cost (acquisition or acquisition plus logistic support cost).

The models could be used in the early conceptual and validation phases to establish reliability requirements.

To exercise the models, one must be able to (1) specify the mission profile by phases and the subsystem operating time during each phase; (2) identify mission critical subsystems and specify MTBF's; (3) determine the conditional probabilities of aborting given a subsystem failure.

8. APPLICABILITY TO DP&E-110: The models developed in this paper provide a means of improving reliability, and through reliability improvement, lowering of O&S costs. Potentially the models could provide a complex but useful approach to the task as it relates to spares and maintenance frequency.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 23

2. TITLE: *Life Cycle Cost of Modular Electronic Equipment*

3. AUTHOR: INSTITUTION: DATE: B. Dale Teague; Naval Avionics Facility, Indianapolis; November 1973.

4. PREPARED FOR: Author's Institution

5. 25 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, NAFI-TR-1980.

7. BRIEF SUMMARY: A mathematical model (accounting build-up) is given for computing the relative LCC of electronic equipment using different modular packaging techniques so that trade-off decisions can be made regarding module size, number of module types, and reliabilities.

8. APPLICABILITY TO DP&E-110: Because the model focuses on some of the LCC, namely that directly related to a module and excluding connecting panels and support structures, the output is highly specialized and incomplete.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 24

2. TITLE: *Research Study of Radar Reliability and Its Impact on LCC for the APQ-113, -114, -120, and -144 Radars*

3. AUTHOR: INSTITUTION: DATE: Staff Report; Aerospace Electronic Systems Department, General Electric; April 1973.

4. PREPARED FOR: Deputy for Engineering, ASD, AFSC

5. 248 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, F 33615-72-C-1354, Project No. 327F.

7. BRIEF SUMMARY: This study presents in great detail the usefulness of reliability activities to LCC control. Specifically four radars are addressed.

8. APPLICABILITY TO DP&E-110: Detailed examinations of specific avionics equipment reliability techniques provide a familiarity with terminology and procedures used by commercial contractors to assess reliability.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 25

2. <u>TITLE:</u> *On the Reduction of Operating and Support Costs of Air Force Aircraft*

3. <u>AUTHOR: INSTITUTION: DATE:</u> Russell M. Genet; PRAM Program Office, ASD; March 10, 1976.

4. PREPARED FOR: Author's Institution

5. 18 pages

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE:</u> Unclassified, RAXA-76-3

7. <u>BRIEF SUMMARY:</u> This is a speculative paper summarizing current perspectives of how to improve O&S costs on Air Force aircraft.

8. <u>APPLICABILITY TO DP&E-110:</u> Although not directly applicable, the discussion of O&S conceptual approaches provides useful background on the foundation of O&S difficulties.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 26

2. TITLE: *Handbook for the Implementation of the Design to Cost Concept*

3. AUTHOR: INSTITUTION: DATE: Richard H. Anderson and Thomas E. Dixon; Directorate for Aerospace Studies, Kirtland, AFB; February 1975.

4. PREPARED FOR: Author's Institution

5. 104 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, SA-TR-75-2.

7. BRIEF SUMMARY: This report provides a set of rationales and procedures for implementation of the Mission Completion Success Probability (MCSP) model, and the Designing to System Performance/Cost (DSPC) model.

8. APPLICABILITY TO DP&E-110: These models provide technical means to implement design-to-cost acquisitions. Reliability goals and cost optimization given those goals are the real outputs of these approaches.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 27

2. TITLE: *Cost Estimating Relationships Using Linear, Log-Linear and Non-Linear Regression*

3. AUTHOR: INSTITUTION: DATE: J. E. Bilikam; Air Force Avionics Laboratory (AFAL), Wright-Patterson Air Force Base; April 1975.

4. PREPARED FOR: Air Force Avionics Laboratory

5. 14 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AFAL-TR-75-43.

7. BRIEF SUMMARY: Based on earlier work sponsored by AFAL, this paper attempts to utilize weighted regression and non-linear regression analyses to produce improved avionics cost estimating relationships.

The costs for which equations are created are computer production costs (non-linear and weighted equations) and radar development costs (non-linear).

8. APPLICABILITY TO DP&E-110: The usefulness of this paper is in the fact that it provides some cook-book examples of avionics cost regressions and some conceptual background concerning the estimating properties of different forms of equations.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 28

2. TITLE: *Proceedings of the Life Cycle Task Group of the Joint Services Data Exchange for Inertial Systems Quarterly Meeting (5th)* held at Redondo Beach, California on 19 March 1974

3. AUTHOR: INSTITUTION: DATE: Russell B. Stauffer (editor); Aerospace Guidance and Methodology Center; November 21, 1974.

4. PREPARED FOR: Author's Institution

5. 140 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AGMC-74-046.

7. BRIEF SUMMARY: The papers discuss the development of the CRIER LCC model.

8. APPLICABILITY TO DP&E-110: Background discussions leading up to CRIER set forth in detail the considerations that went into its structure.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 29

2. TITLE: *Joint Generalized Least Squares Applied to Cost Estimation For Fighter Aircraft*

3. AUTHOR: INSTITUTION: DATE: Patrick W. O'Brien; CPT, USAF; December 1974.

4. PREPARED FOR: Air Force Institute of Technology

5. 95 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AD/A-003-354.

7. BRIEF SUMMARY: The paper examines joint generalized least squares regression as a technique to improve cost estimating relationships for fighter aircraft, including a lump-sum equation for avionics.

The technique of ordinary least squares requires linearity among the variables and assumes independence of the elements of total cost. Joint generalized least squares permits us to assume no covariance between observations within each of several equations for a single TMS, such as equations for airframe, engine, and avionics; and no covariance between types of equations and dissimilar observations, such as the airframe cost estimate for the F-14 and the avionics estimate for the F-18. It does permit us to assume and to test for covariance between types of equations for corresponding observations.

8. APPLICABILITY TO DP&E-110: These technical terms may be translated into practical applicability as follows: if you separately estimate equations for airframe, avionics, and engines using ordinary least squares, you may fail to capture interactions among the variables in the three equations that, if taken into account, could help to reduce the errors in the estimates. Joint generalized least squares permits you to jointly estimate the three equations, capturing the interactions among the variables, thereby reducing estimating errors.

Conceptually applied to support cost estimation, joint generalized least squares could aid in improving estimates for various support costs when there are interactions among the various variables for the various equations.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 30

2. TITLE: *A-7 ALOFT Life Cycle Cost and Measures of Effectiveness Models*

3. AUTHOR: INSTITUTION: DATE: R. A. Greenwall; Naval Electronics Laboratory Center, San Diego; March 1, 1976.

4. PREPARED FOR: Naval Air Systems Command

5. 48 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, NELC Technical Report 1982 (TR1982).

7. BRIEF SUMMARY: The report describes a project to estimate costs for a fiber optics versus a coaxial cable connecting system in fighter aircraft. Because the fiber optics technology is a quantum jump from the existing coaxial cable technology, the use of analogy data for estimating support and other costs was impossible. Instead, expert judgments were used to provide concensus cost inputs into a simple set of accounting equations.

8. APPLICABILITY TO DP&E-110: The description of the process of developing the data inputs provides a case study of utilizing data based primarily on expert judgments.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 31

2. TITLE: *Cost Effectiveness Program Plan for Joint Tactical Communications, Volume III, LCC*

3. AUTHOR: INSTITUTION: DATE: Staff, Operations Research, Test, and Analysis Directorate; TRI-TAC Office; June 1976.

4. PREPARED FOR: Author's Institution

5. 59 pages + 50 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, TTO-ORT-032-76B-V3.

7. BRIEF SUMMARY: This volume is divided into five sections. Section 1 introduces LCC concepts. Section 2 discusses the general structure of an LCC model that uses regression CERs for acquisition costs and build-up engineering estimates for O&S costs. Section 3 presents a general methodology for estimating and analyzing LCC applicable to long range planning and equipment design analyses and trade-off studies. Section 4 presents general background discussions of discounting techniques and the learning curve. Section 5 discusses the relationship between LCC and the DoD DTC program.

8. APPLICABILITY TO DP&E-110: The engineering build-up approach is a potential structure for use in providing relative estimates of O&S costs during conceptual development.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 32

2. TITLE: *Supplemental Life Cycle Costing Program Management Guidance*

3. AUTHOR: INSTITUTION: DATE: John D. S. Gibson; Aeronautical Systems Division; January 1977.

4. PREPARED FOR: ASD Comptroller

5. 27 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: This is an update of the program management guidance first presented in the March 1975 edition of this paper (control number 12 in this series). The major additions are expanded discussions of design and program issues which, if addressed and acted upon, could reduce LCC costs.

Subsystem issues that the program manager should address are:

(1) Subsystem performance

a. Are subsystem performance requirements consistent with required system performance requirements?

b. What are the subsystem performance parameters that significantly affect LCC?

c. How does the level of subsystem performance affect life cycle costs?

(2) Subsystem design concept

a. Design concept

b. Critical subsystem design parameters

c. Subsystem design simplicity

d. Use of proven components

e. Design commonality

f. Design standardization

g. Design materials selection

h. Other

(3) Subsystem reliability

(4) Subsystem maintainability

a. Maintenance philosophy

b. Component placement

c. Maintenance accessibility

d. Support equipment

e. Maintenance procedures.

8. APPLICABILITY TO DP&E-110: Like the earlier version, this paper offers insights into the program manager's approach to LCC in the Air Force.

1. **DP&E-110 RESEARCH MATERIAL CONTROL NUMBER:** 33

2. <u>**TITLE:**</u> *The Impact of Required Contractual Clauses on System Acquisition Policies: The Case of Value Engineering*

3. <u>**AUTHOR: INSTITUTION: DATE:**</u> Geneese G. Baumbusch; RAND; September 1975.

4. <u>**PREPARED FOR:**</u> RAND/Analytical Services Office

5. 43 pages

6. <u>**CLASSIFICATION, IDENTIFYING NUMBER OR CODE:**</u> Unclassified, RAND R-1722-PR.

7. <u>**BRIEF SUMMARY:**</u> This paper discusses the role of "value engineering" in DTC programs. Value engineering is defined in the ASPRs as "...concerned with the elimination or modification of anything that contributes to the cost of a contract item or task but is not necessary for needed performance, quality, maintainability, reliability, or interchangeability."

The paper offers a brief history of value engineering in DoD, and this history is embodied in issues as they evolved over time. A sample of these issues includes discussions of the failure of value engineering clauses to reduce costs, the necessity to reassess the risk assumption in contracting arrangements, and the impact of design-to-cost processes on concepts of profitability and cost.

8. <u>**APPLICABILITY TO DP&E-110:**</u> Specific procurement regulations are discussed in detail, providing an important element of background understanding of the institutional structure of procurements in general.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 34

2. TITLE: *Major System Acquisitions: A Discussion of the Application of OMB Circular No. A-109*

3. AUTHOR: INSTITUTION: DATE: Office of Federal Procurement Policy, Office of Management and Budget; Executive Office of the President; August 1976.

4. PREPARED FOR: Office of Management and Budget

5. 36 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, UFPP Pamphlet No. 1.

7. BRIEF SUMMARY: This pamphlet discusses the changes in the Major System Acquisition policy to which DODD 5000.1 and DODD 5000.2, both dated January 18, 1977, are responses. It discussed OMB circular A-109, entitled Major System Acquisitions.

The concept which DoD embodied in the Mission Element Needs Statement is discussed here as is the specific decision point identification of DSARC 0.

This also contains the requirement that subsystems which are candidates for inclusion in a major system acquisition program are not to be fully developed until the subsystem is identified as part of a system proposal for full-scale development.

8. APPLICABILITY TO DP&E-110: This document offers background discussion of the policies for major system acquisition that are contained in the newly revised DODD's 5000.1 and 5000.2.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 35

2. <u>TITLE:</u> *Joint Logistics Commanders Guide on Design-to-Cost (Life Cycle Cost as a Design Parameter)*

3. <u>AUTHOR: INSTITUTION: DATE:</u> Joint Logistics Commanders Staffs (AFLC, AFSC, CNM, AMC); January 1976.

4. <u>PREPARED FOR:</u> Author's Institution

5. 55 pages

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE:</u> Unclassified, (no identifying number or code).

7. <u>BRIEF SUMMARY:</u> This guide provides information for application of DTC concepts contained in DODD 5000.28.

8. <u>APPLICABILITY TO DP&E-110:</u> Although 5000.28 has been eliminated by the new DODI 5000.1 and 5000.2, the definitions and institutional structures discussed in the guide are still useful background.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 36

2. TITLE: *A Comparative Survey of Aircraft Maintenance Manpower Estimation in the Services*

3. AUTHOR: INSTITUTION: DATE: W. S. Furry, C. D. Roach, J. F. Schank; RAND; November 1976.

4. PREPARED FOR: OSD/Director of Planning and Evaluation

5. 87 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, RAND Working Note WN-9652-1-DP&E.

7. BRIEF SUMMARY: The paper summarizes the progress to date on a project to develop predictive maintenance manpower models applicable to the early phases of the weapon system acquisition process. The research survey examines maintenance manpower prediction methods in the Army, Navy, and Air Force. Of prime interest is the Air Force Logistics Composite Model (LCOM).

8. APPLICABILITY TO DP&E-110: Three general evaluative comments in the paper directly impact our avionics support cost estimation project. First, the authors note that MTBF and MTTR provide only partial explanations for the maintenance manpower requirements of new weapons. Reliability (MTBF) is typically defined as all failures regardless of their impact on weapon system availability. Maintainability (MTTR) is a measure of the time required to inspect, service, and repair the weapon system. Both MTBF and MTTR ignore manning policies which directly affect the total manpower requirement.

Second, MTBF and MTTR imply a casual relationship between flying hours and maintenance requirements. Some maintenance tasks are related to number of landings or take-offs, or engine cycles, or calendar time. Thus, a change in flying hours does not necessarily produce a direct change in maintenance requirements.

Third, it is unclear that there is a direct functional relationship between MTBF and MTTR and personnel requirements. The number of units of equipment maintained by a work center, shop organization, shift requirements, and the distribution of occupational specialities all affect manpower requirements. Thus, increased reliability or maintainability may not result in personnel savings.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 37

2. TITLE: *Electronically Agile Radar System/Cost Effectiveness Program Plan*

3. AUTHOR: INSTITUTION: DATE: (Author unknown); Westinghouse Electric Corporation Systems Development Division; December 10, 1975.

4. PREPARED FOR: Author's Institution

5. 81 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AOOK (KI-S-3569/S-145-1).

7. BRIEF SUMMARY: This paper provides a summary of the results of the EAR (Electronically Agile Radar) program, which was designed to provide a test case for an LCC tailored acquisition program for a specific avionics equipment. The O&S costs were estimated with a variant of the Air Force LSC model.

8. APPLICABILITY TO DP&E-110: A detailed application of the LSC model is presented which provides a cook-book example of how LSC can be used.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 38

2. <u>TITLE:</u> *The AFSATCOM Life Cylce Cost Model*

3. <u>AUTHOR: INSTITUTION: DATE:</u> J. H. James and W. M. Stein; MITRE; December 1976.

4. <u>PERFORMED FOR:</u> USAF Electronics Systems Division

5. 145 pages

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE:</u> Unclassified, MITRE MTR-3057, ESD Project No. 6340.

7. <u>BRIEF SUMMARY:</u> An LCC model is presented for the Air Force Satellite Communications System (AFSATCOM). The model is a variant of the LSC model.

8. <u>APPLICABILITY TO DP&E-110:</u> A detailed application of the LSC model is presented which provides a cook-book example of how LSC can be used.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 39

2. TITLE: *Maintenance Manpower as a Cost Consideration During Weapon System Acquisition*

3. AUTHOR: INSTITUTION: DATE: Michael L. York; Air Command and Staff College; May 1975.

4. PREPARED FOR: Author's Institution

5. 38 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: The paper assesses the past history of maintenance manpower estimation as an element of LCC, and includes evaluations of LCOM and other maintenance manpower estimating techniques.

8. APPLICABILITY TO DP&E-110: Both speculative and factual, the paper provides a useful introduction to maintenance manpower estimating as a part of overall LCC estimating.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 40

2. TITLE: *Review of the Application of Life Cycle Costing to the ARC-XXX/ARC-164 Program*

3. AUTHOR: INSTITUTION: DATE: (Author unknown); USAF Avionics Program Office, Aeronautical Systems Division, Wright-Patterson AFB; August 1974.

4. PREPARED FOR: USAF Avionics Program Office, Aeronautical Systems Division, Wright-Patterson AFB

5. 30 pages + 17 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: The ARC-XXX/ARC-164 Command UHF Radio Modernization Program was a two-phased effort. The first phase was the qualification of three contractors who were awarded contracts to build and qualify candidate radios to Air Force specifications. The second phase was the release of the production RFP to the production contractors. During this second phase the contractors were required to submit LCC estimates. The major decision variable was the LCC submission of each contractor.

8. APPLICABILITY TO DP&E-110: The ARC-164 program was a test case for LCC as the major decision parameter in an avionics acquisition program.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 41

2. TITLE: *Program LCC Documentation, Version 2*

3. AUTHOR: INSTITUTION: DATE: R. K. Gates, M. J. Abraham; The Analytic Sciences Corporation; April 28, 1976.

4. PREPARED FOR: Aeronautical Systems Division, Air Force Systems Command

5. 60 pages + 167 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, Technical Report 747-3.

7. BRIEF SUMMARY: The paper reports on Life Cycle Cost (LCC), a computer program for calculating life cycle costs involved in procuring and maintaining avionics equipment. The program is a massive accounting model at the LRU and SRU levels, requiring more separate data inputs associated with each LRU and SRU than are required by the AFLC LSC model. To date, the program has not been used to assess life cycle costs of a major procurement.

8. APPLICABILITY TO DP&E-110: The paper provides an example of the standard accounting model approach to life cycle costing.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 42

2. TITLE: *The A-7 ALOFT Cost Model: A Study of High Technology Cost Estimating*

3. AUTHOR: INSTITUTION: DATE: R. L. Johnson, E. W. Knobloch; U.S. Naval Postgraduate School; December 1975.

4. PREPARED FOR: Naval Electronics Laboratory Center, North Island, California

5. 270 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, AD/A-021-913.

7. BRIEF SUMMARY: The A-7 Airborne Light Optical Fiber Technology (ALOFT) economic analysis is being conducted to identify and evaluate the life cycle costs and benefits associated with a fiber optic point-to-point aircraft data transfer system. Once identified, the costs and benefits are compared with the costs of conventional coaxial cable. Then, on the basis of lowest life cycle costs, a decision will be made whether to replace coaxial cables on the A-7 aircraft with fiber optics systems.

The model is an accounting model similar to the AFLC LSC model, and it is specially tailored to the A-7 and fiber optics.

8. APPLICABILITY TO DP&E-110: The model is another example of accounting model application to avionics equipments.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 43

2. TITLE: *Improved Life Cycle Cost Estimating*

3. AUTHOR: INSTITUTION: DATE: C. E. Earnhart; McDonnell Aircraft Company; December 22, 1976.

4. PREPARED FOR: McDonnell-Douglas Corporation

5. 25 pages + 25 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, Report Number MDC A4563.

7. BRIEF SUMMARY: This paper examines both the theoretical and empirical foundations for the top level support cost equations utilized by McDonnell Aircraft for the F-18 program. Data bases are discussed and assessed in terms of strengths and weaknesses. Each equation in the F-18 top level model is examined in considerable detail.

8. APPLICABILITY TO DP&E-110: This is a valuable document that provides an opportunity to understand the strengths and weaknesses of the F-18 top level model equations.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 44

2. TITLE: *Life Cycle Cost*

3. AUTHOR: INSTITUTION: DATE: J. J. Sinnott; McDonnell Aircraft Company; February 7, 1977.

4. PREPARED FOR: Naval Air Systems Command, F-18 Program Manager, Air

5. 35 pages + 12 pages of appendixes

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, MDC A4041-6.

7. BRIEF SUMMARY: This paper is part of the contractual requirement for F-18 life cycle cost reporting by the McDonnell Aircraft Company to the Naval Air Systems Command. It provides an example of exactly how support costs are reported and tracked in the Navy's current fighter development program.

8. APPLICABILITY TO DP&E-110: The usefulness of this paper is to provide a review of the techniques for support costing with the NAVAIR-MCAIR top level equations.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 45

2. <u>TITLE:</u> *Quantitative Model Used in the RIW Decision Process*

3. <u>AUTHOR: INSTITUTION: DATE:</u> R. K. Gates, R. S. Bicknell, J. E. Bortz; The Analytic Sciences Corporation; 1977.

4. <u>PREPARED FOR:</u> Proceedings of the 1977 Annual Reliability and Maintainability Symposium

5. 8 pages

6. <u>CLASSIFICATION, IDENTIFYING NUMBER OR CODE:</u> Unclassified, (no identifying number or code).

7. <u>BRIEF SUMMARY:</u> This paper provides a conceptual discussion of quantitative models useful for government and contractor decisions in the implementation of reliability improvement warranties. As an example, one contractor pricing model is

$$W = P + C_W + \frac{Q_T U t_W}{MTBF_a} Cr + I(MTBF_a) + D_t,$$

where:

- W = fixed price paid to the contractor for the warranty
- P = profit
- C_W = fixed costs to the contractor
- Q_T = total number of systems to be delivered
- U = usage rate in operating time per calendar time
- t_W = duration of warranty period
- $MTBF_a$ = achieved MTBF-average over the RIW period
- C_r = cost to the contractor per unit of repair
- $I(MTBF_a)$ = cost of improvement actions to achieve $MTBF_a$
- D_t = damages for not meeting the turnaround time requirement.

8. <u>APPLICABILITY TO DP&E-110:</u> The usefulness of this paper is to identify the standard quantative approaches and their relevant variables for costing warranties. Although not

explicitly evaluated in DP&E-110, warranties were considered in the initial stages of research on the paper.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 46

2. TITLE: *Historical and Forecasted Aeronautical Cost Indices*

3. AUTHOR: INSTITUTION: DATE: Craig Lentzsch, William D. Bandt, Cost Analysis Division, Comptroller; Aeronautical Systems Division; May 1973.

4. PREPARED FOR: Cost Analysis Division, Comptroller, Aeronautical Systems Division

5. 55 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, Aeronautical Systems Division Report 110A.

7. BRIEF SUMMARY: This report presents both historical and forecast aerospace cost indices for cost estimators at the USAF Aeronautical Systems Division. Using BLS and ASD cost data, historical indices for airframe development, airframe production, engine development, engine production, avionics development, and avionics production were developed.

8. APPLICABILITY TO DP&E-110: The indices provide examples of how avionics prices have varied over time.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 47

2. TITLE: *Aircraft Operating and Support Cost Impacts of Support Concepts and Design Characteristics: Volume II, Improved Regression Through Biased Estimators - Theory and User Program*

3. AUTHOR: INSTITUTION: DATE: L. W. Schlipper; TRACOR, Inc.; March 17, 1976.

4. PREPARED FOR: Naval Aviation Integrated Logistic Support Center

5. 178 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, NAILSC Report No. 02-12-1.

7. BRIEF SUMMARY: This report describes a theory of biased estimators which operate more accurately than ordinary least squares regression for minimizing multicollinearity. Also included are a brief discussion of linear regression theory; an evaluation of the measures of error relevant to the techniques of interest; a discussion of ordinary least squares methodology; and an evaluation of the role of multicollinearity in least squares regression.

8. APPLICABILITY TO DP&E-110: This paper provides an analytical review and speculative evaluations of various regression techniques potentially applicable to avionics (and other) cost estimation.

1. DP&E-110 RESEARCH MATERIAL CONTROL NUMBER: 48

2. TITLE: *Proceedings of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems - Quarterly Meeting July 1975.*

3. AUTHOR: INSTITUTION: DATE: Edited by Russell B. Stauffer; Newark Air Force Station; July 31, 1975.

4. PREPARED FOR: Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems

5. 228 pages

6. CLASSIFICATION, IDENTIFYING NUMBER OR CODE: Unclassified, (no identifying number or code).

7. BRIEF SUMMARY: In addition to reviewing the progress on the CRIER accounting model through mid-1975, the edited papers include several of usefulness to the DP&E-110 avionics support cost study research. The papers are:

   (1) "Design to Cost Implications of Life Cycle Cost," by Bob Adel and Frank Merlino of Northrop Corporation.

   (2) "The CONUS NAV VOR/ILS Radio-RIW Requirements and Prices," by Earl I. Feder and Richard A. Kowalski, U.S. Army Electronics Command and ARINC Corporation.

   (3) "Inertial Gyro Life Cycle Costs Analysis and Management," by Peter J. Palmer, Charles Stark Draper Laboratory.

   (4) "Failure Free Warranty Reliability Improvement Warranty Buyer Viewpoints," by Oscar Markowitz.

   (5) "Army Utilization of Life Cycle Costing," by Thomas E. McGuire, U.S. Army Materiel Command, Project Manager Navigation/Control Systems.

   (6) "F-16 Air Combat Fighter Life Cycle Cost Program," by Perry C. Stewart, AFLC.

   (7) "Avionics Proliferation, A Life Cycle Cost Perspective," by Russel M. Genet and Thomas D. Meitzler, AGMC, Newark Air Force Station.

8. APPLICABILITY TO DP&D-110: Specific elements of the CRIER model are discussed and explained.

APPENDIX B

MILITARY STANDARD 780E(AS)
WORK UNIT CODES

MIL-STD-780E (AS)
1 December 1975

MILITARY STANDARD

WORK UNIT CODES

FOR AERONAUTICAL EQUIPMENT; UNIFORM NUMBERING SYSTEM

DEPARTMENT OF THE NAVY

NAVAL AIR SYSTEMS COMMAND

WASHINGTON, D.C. 20360

1. This standard has been approved by the Naval Air Systems Command and is published to provide a uniform numbering system for the assignment of work unit codes for aeronautical equipments.

2. Use of this standard by activities under the cognizance of the Naval Air Systems Command shall be mandatory effective on date of issue.

3. The assignment, management and coordination of work unit codes for aeronautical equipment shall be the responsibility of the Naval Air Technical Services Facility (NAVAIRTECHSERVFAC) Code 331, 700 Robbins Avenue, Philadelphia, Pennsylvania 19111. Work unit codes shall be obtained by official correspondence with NAVAIRTECHSERVFAC.

4. Recommended corrections, additions, or deletions to this standard should be addressed to Commander, Naval Air Systems Command, AIR-411B, Navy Department, Washington, D.C. 20360.

CONTENTS

MILITARY STANDARD

WORK UNIT CODES

FOR AERONAUTICAL EQUIPMENT;
UNIFORM NUMBERING SYSTEM

1. SCOPE.

1.1 Scope. This standard prescribes the numbering system to be used for the coding of hardware items in the preparation of work unit code manuals.

2. APPLICABLE DOCUMENTS.

2.1. The aeronautical requirements, specifications, standards, and instructions contained herein are applicable to the establishment of work unit code requirements for aeronautical weapon systemps, ground support equipment, weapon system trainers, and related systems.

AERONAUTICAL REQUIREMENTS:

NAVAIR AR-21	**Aeronautical Requirement Ground Support Equipment**
NAVAIR AR-30	**ILS Program Requirements for Aeronautical Systems and Equipment**
NAVAIR AR-87	**Work Unit Code Lists; Preparation of**

SPECIFICATIONS:

MIL-N-18307	**Nomenclature and Identification Electronic, Aeronautical, and Aeronautical Support Equipment Including GSE**
MIL-M-23782 (AS)	**Manuals Technical: Work Unit Code Manuals, Preparation of**

STANDARDS:

MIL-STD-12	**Abbreviations for use on Drawings, Specifications, Standards and in Technical Documents**

MIL-STD-196	Joint Electronic Type Designation System
MIL-STD-875	Type Designation System for Aeronautical and Support Equipment
MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-1388-2	Logistic Support Analysis Data Elements Definition
USAS Y32.16	Reference Designations for Electrical and Electronic Parts and Equipment

INSTRUCTIONS:

OPNAVINST 4790.2	Naval Aviation Maintenance Program
NAVSUP 4423.14	Uniform Source Maintenance and Recoverability Codes

3. DEFINITIONS.

3.1 For the purpose of this Standard, the terms listed herein are defined as follows:

ON EQUIPMENT — The term applies to maintenance work which can be performed at or on the weapon or equipment while it is located on line or in the hanger.

IN SHOP — Maintenance work which requires the use of shop facilities and which cannot be normally performed outside of the shop. (Bench test, component disassembly, and repair are examples of in-shop maintenance work.)

SYSTEM — A grouping of equipments which is a major part of a weapon system. Examples include Landing Gear System, Flight Control System, Radar Navigation System. The first two digits of the work unit code identify the type of system. (Refer to 4.2.2.1)

SUBSYSTEM -- Equipment which performs a specific function in the overall operation of the system. Examples include forward fuselage, main landing gear, air conditioning. The third digit of the code distinguishes engine models in those instances when three digits are used exclusively. The third digit in conjunction with the fourth digit identifies a complete avionics set. (See 4.2.2.2 and 4.2.2.3)

COMPONENT/ASSEMBLY — A number of parts or subassemblies or any combination thereof joined together to perform a specific function. This term applies to items which cannot be further disassembled for test or repair without the aid of shop facilities. Examples include Liquid Oxygen Converter, Receiver Transmitter, Refrigeration Unit, Fuel Control. The fifth digit of the code is normally used to identify components and assemblies. (Refer to 4.2.2.4)

PART — One piece which is not normally subject to disassembly. The sixth digit (and seventh digit when used) identifies a part. (Refer to 4.2.2.5 and 4.2.2.6)

WEAPON SYSTEM — Aircraft, missiles, target drones, rockets, and trainers are functionally related. The establishment of coding for these weapon systems shall be developed in a similar manner.

REPAIRABLE ITEM — An item of durability which when unserviceable can be economically restored to a serviceable condition through normal repair procedures in accordance with the appropriate SM&R codes.

3.1.1 **System Codes.** System codes are the first two digits of a work unit code. They identify the types of systems or support equipment and are listed in paragraphs 3.1.2 and 3.1.3, respectively.

3.1.2 **Weapon Systems.**

AIRCRAFT/MISSILE/TRAINER

11 AIRFRAME................................ Includes the structural part of the weapon system. Structure of a training device may include platform, housing and decking.

12 FUSELAGE COMPARTMENTS... Embraces furnishings and equipment in the cockpit, navigator's compartment and other stations.

13 LANDING GEAR........................ Incorporates landing gear, catapult and arresting systems.

14 FLIGHT CONTROLS................. Numbers all moveable flight control surfaces.

15 HELICOPTER ROTOR SYSTEM. Includes rotors, hubs and swashplates or in trainers, substitutes for such aircraft hardware.

16 ESCAPE CAPSULES AND SYSTEMS.................................. Includes escape capsules and/or integrated escape systems.

18 MODIFIED/SIMULATED AIRCRAFT ASSEMBLIES.......... Incorporates trainer equipment that provides by simulation the functions of an actual aircraft assembly. Also includes systems that simulate, for the trainer, an aircraft's static and dynamic characteristics and forces.

19 TRAINER ENVIRONMENTAL SIMULATORS............................ Includes simulators which produce visual, aural or physical effects.

POWER PLANTS

21 RECIPROCATING ENGINES — Embraces opposed and radial-type reciprocating engine sections (nose, power, supercharger) and engine systems (fuel, lubrication, ignition and exhaust).

22 TURBOSHAFT ENGINES — Covers turboprop/turboshaft engine sections (compressor, turbine, and combustion) and engine systems (fuel, lubrication, ignition and bleed air).

23 TURBOJET ENGINES — Includes turbojet engine sections (compressor, turbine, exhaust, accessory drive) and engine systems (oil, fuel, ignition, electrical).

24 AUXILIARY POWER PLANT (AIRBORNE) — Comprises reciprocating and turbine engine-driven airborne APUs.

25 PROPULSION SYSTEMS - MISSILES — Includes solid propellent and liquid propellent rocket motors.

26 HELICOPTER, VTOL AND STOL POWER TRANSMISSION — Comprises drive shafts, brakes, and gear boxes transmitting engine power.

27 TURBOFAN ENGINES — Covers turbofan engine sections and systems. Sections and systems are similar to those listed in item 23 with the addition of a fan.

29 POWER PLANT INSTALLATION — Incorporates power plant supports and mounts, control levers, starting systems, approach power compensating sets, and other systems that are part of the basic engine.

PROPELLERS

32 HYDRAULIC PROPELLERS — Embraces hydraulically-operated propeller assemblies; propeller accessories such as governors, deicing/antiicing systems, spinners, and synchrophasers and mechanical control devices.

UTILITIES

41 AIR CONDITIONING, PRESSURIZATION and SURFACE ICE CONTROL .... Includes refrigeration units, cabin conditioning and equipment cooling systems, defogging and antiice systems.

42 ELECTRICAL POWER SUPPLY .... Covers AC and DC power sources, electrical wiring, power conversion and control and regulating equipment.

44 LIGHTING SYSTEM .... Incorporates all interior including panel and exterior including emergency lighting systems.

45 HYDRAULIC AND PNEUMATIC POWER .... Covers hydraulic and pneumatic power sources. Does not include air-drive turbine systems.

46 FUEL SYSTEM .... Embraces internal and external tanks, refueling and defueling equipment and distribution systems.

47 OXYGEN SYSTEM .... Consists of the installed oxygen system.

49 MISCELLANEOUS UTILITIES .... Comprises fire detection, fire extinguishing, rain repellant, caution/advisory, and air-drive turbine systems.

INSTRUMENTATION

51 INSTRUMENTS, GENERAL .... Comprises standard flight instruments, engine instruments, navigational instruments, fuel quantity instruments, and pitot static system.

52 AUTOPILOT .... Consists of automatic pitch, yaw and roll control systems when not a part of an integrated guidance and flight control system.

53 GUIDANCE SYSTEMS (DRONE) Incorporates the guidance and flight control equipment installed in a drone.

54 TELEMETRY .... Includes transmitting sets, receivers/recorders, and sensors/transducers which send data from one station to another.

56 FLIGHT REFERENCE .... Includes attitude computer groups, vertical and flight reference sets, compass sets, attitude heading reference sets, air data computers and vertical gyro systems.

57 INTEGRATED GUIDANCE AND FLIGHT CONTROL .... Covers aircraft and missile integrated guidance and control systems. Also includes autopilots that are part of an integrated system.

58 IN-FLIGHT TEST EQUIPMENT .. Incorporates installed test consoles and in-flight performance monitors.

59 TARGET SCORING AND AUGMENTATION .... Embraces scoring acquisition and augmentation equipment including visual augmentation (smoke generator) systems.

COMMUNICATIONS

61 HF COMMUNICATION SYSTEMS

62 VHF COMMUNICATION SYSTEMS

63 UHF COMMUNICATION SYSTEMS

64 INTERPHONE SYSTEM

65 IFF

66 EMERGENCY RADIO

67 CNI

69 MISCELLANEOUS COMMUNICATIONS .... Includes digital data communications systems, sound recorders, antennas and communication equipment not specified in other systems.

NAVIGATION, BOMBING FIRE CONTROL, WEAPON DELIVERY ECM and PHOTOGRAPHIC/RECONNAISSANCE

71 RADIO NAVIGATION .... Includes airborne radio navigational systems and aidc.

72 RADAR NAVIGATION .... Incorporates airborne radar navigational systems and aids.

73 BOMBING-NAVIGATION........... Covers systems and components used specifically to navigate to and from a bombing mission.

74 WEAPON CONTROL .... Comprises target acquisition and tracking systems, weapon direction and control equipments.

75 WEAPON DELIVERY .... Incorporates installed launch and related eject mechanisms, gun systems and ammunition feed equipments.

76 ELECTRONIC COUNTERMEASURES .... Embraces chaff dispensers, aural and visual warning systems, passive defense systems, search receivers, jamming transmitters, and track breaking equipment.

77 PHOTOGRAPHIC/ RECONNAISSANCE .... Incorporates cameras, magazines, filters, controls, dehydrators, heaters, exposure counters, vibration isolators, intervalometers, bomb damage evaluators and recorders and small reconnaissance radar sets.

78 MODIFIED/SIMULATED TRAINING DEVICE (Instrumentation Communications) .... Covers training devices that provide the functions of an avionics system by simulating situations.

79 MODIFIED/SIMULATED TRAINING DEVICE (Navigation/Bombing Fire Control/ Weapon Delivery/ECM/Photographic Reconnaissance) .... Includes training devices that provide the functions of an avionics system by simulating situations.

MISSILES/ROCKETS

81 WARHEAD

82 FUSING/SAFE-ARM/DESTRUCT/RANGE SAFETY

83 BOOSTER STAGE SEPARATION

85 MISSILE and ROCKET CONTAINERS

MISCELLANEOUS EQUIPMENTS/SYSTEMS

87 TRAINING DEVICE VISUAL DISPLAYS .... Comprises systems that provide visual displays such as landing presentations and three-dimensional target displays.

88 TRAINING DEVICE INSTRUCTION AIDS .... Includes equipment that enhances the training process by providing a permanent, stop-action, or non-permanent record of the mission.

89 COORDINATE and RELATIVE POSITION COMPUTATION SYSTEMS .... Incorporates training device computation systems that provide relative and coordinate positions of aircraft, ships, submarines, stations; which are unique to a training exercise.

91 EMERGENCY EQUIPMENT .... Covers fire fighting equipment, medical equipment, signal guns, survival equipment such as parachutes, life rafts, and personnel warning system components.

92 TOW TARGET SYSTEMS .... Comprises tow targets and miscellaneous tow equipment, reel hydraulic systems, target reels, carriers and containers.

93 DECELERATION EQUIPMENT/DROGUE PARACHUTE .... Embraces deceleration/drogue parachutes, release mechanisms and deceleration parachute enclosure operating systems.

94 METEOROLOGICAL EQUIPMENT .... Covers airborne atmospheric and weather data gathering systems and equipment. Also includes ground automatic weather stations.

96 PERSONNEL EQUIPMENT.......... Includes aviators' clothing and breathing (oxygen) equipment which is issued to flight crews for their personal use.

97 EXPLOSIVE DEVICES .... Incorporates cartridges used in ejection seats, seat catapult/rockets, starter impulse cartridges, fire extinguisher cartridges, and weapons release devices.

99 TRAINING DEVICE GENERAL PURPOSE COMPUTERS and INTERFACE HARDWARE.......... Covers general purpose analog and digital computers which are programmed and controlled for functional integration into the training device system. Also, includes interface components such as processors, I/O registers, data converters, and circuitry which functions as an extension of the computer.

3.1.3 SUPPORT EQUIPMENT SYSTEMS.

11 CLEANING/CORROSION/PRESERVATION EQUIPMENT — Incorporates steam and high pressure water cleaners, aircraft oil and hydraulic system and component cleaners, ultrasonic cleaners, mobile cleaning units, and preservation/depreservation machines.

12 HEATING/AIR CONDITIONING/VENTILATION — Covers preheaters, heating units, blowers, air conditioning units, ventilating units, dehydrators and dehumidifiers.

13 ARMAMENT RELATED SERVICING EQUIPMENT — Embraces tow reel wire servicing stands, fuel gelling/mixing units, and weapons ancillary equipment.

14 AIR COMPRESSORS — Includes reciprocating engine powered air compressors.

15 OXYGEN/NITROGEN SERVICING EQUIPMENT — Comprises oxygen servicing equipment, nitrogen servicing equipment, and oxygen/nitrogen plants.

19 MISCELLANEOUS SERVICING EQUIPMENT — Incorporates preoilers, vacuum pumps, battery chargers, lighting and illumination equipment, crash and rescue equipment, and water/alcohol servicing equipment.

21 HANDLING EQUIPMENT — Covers engine/airframe handling equipment, aircraft boarding stands/ramps, and weapons handling/transport equipment.

22 LOADING EQUIPMENT — Comprises weapons loading equipment, lift trucks and cranes, support equipment hoists, aircraft cargo/hoists/winches, and armament hoists/winches.

23 TRANSPORT AND TOWING EQUIPMENT — Embraces aircraft towing tractors, special purpose towing equipment, and transportation vehicles/trailers.

31 MAINTENANCE EQUIPMENT — Includes aircraft maintenance platforms, maintenance jeeps/trucks/vans/trailers, honing machines, and balancers.

34 ENGINE TEST EQUIPMENT — Covers turbo engine test stands/facilities, engine test stand starting units, and engine analyzers.

35 ACCESSORIES TEST EQUIPMENT — Comprises starter test stands, propeller test and check equipment, constant speed drive test equipment, lubricating units and pressure gauge testers, and actuator testing equipment.

36 HYDRAULIC TESTING EQUIPMENT — Embraces hydraulic system test stands and hydraulic component test stands.

37 UTILITIES/GENERAL TEST EQUIPMENT — Incorporates pneumatic and oxygen system component test stands, load banks, and hydraulic pressure supplying equipment.

38 CHECK/INSPECTION EQUIPMENT — Includes physical properties inspection units, fuel integrity testers, and weighing equipment.

42 GAS TURBINE COMPRESSOR UNITS — Covers pods, enclosures and trailers.

43 AIR/ELECTRICAL STARTING SYSTEMS — Includes flight line electrical distribution systems and air start systems.

44 ELECTRICAL GENERATION UNITS — Embraces gasoline and diesel engine driven, and electric motor driven, generator units.

48 GROUND SUPPORT EQUIPMENT ENGINES — Comprises gasoline and diesel reciprocating engines, and gas turbine engines.

51 INSTRUMENT TEST AND CHECK EQUIPMENT — Comprises test equipment utilized to test standard flight, engine, and navigation instruments, fuel quantity indicators and pitot static systems.

52 AUTOPILOT TEST AND CHECK EQUIPMENT — Includes test equipment utilized to check pitch, yaw, and roll control systems which are not part of an integrated guidance and flight control system.

53 DRONE GUIDANCE TEST AND CHECK EQUIPMENT — Incorporates the test and check equipment required to support drone guidance systems.

54 TELEMETRY TEST AND CHECK EQUIPMENT — Incorporates the test and check equipment required to support telemetry systems.

56 FLIGHT REFERENCE TEST AND CHECK EQUIPMENT — Covers the test and check equipment required to support flight reference systems and integrated guidance and flight control systems.

61-69 COMMUNICATIONS TEST AND CHECK EQUIPMENT — Covers the test and check equipment required to support communications/interphone systems, IFF, emergency radio, CNI integrated packages, and digital data communications systems.

71-73 NAVIGATION TEST AND CHECK EQUIPMENT — Embraces the test and check equipment required to support radio, radar and bombing navigation systems.

74 WEAPON CONTROL TEST AND CHECK EQUIPMENT — Incorporates the test and check equipment required to support weapon control systems.

75 WEAPON DELIVERY TEST AND CHECK EQUIPMENT — Comprises the test and check equipment required to support weapon delivery systems and related equipment.

76 ECM TEST AND CHECK EQUIPMENT — Includes the test and check equipment required to support electronic countermeasures systems.

77 PHOTOGRAPHIC AND RECONNAISSANCE TEST AND CHECK EQUIPMENT — Covers the test and check equipment required to support photographic and reconnaissance systems.

78 MULTIFUNCTION/MULTIAPPLICATION EQUIPMENT — Consists of equipment that is specifically excluded from support equipment coded in systems 51 through 77, 79, 81, 92 and 98.

79 GENERAL AVIONICS CHECK AND TEST EQUIPMENT — Embraces the test and check equipment commonly referred to as general purpose or ground support equipment.

81 MISSILE TEST AND CHECK EQUIPMENT — Comprises the check and test equipment for missiles and related equipment.

92 WEAPON SYSTEM PECULIAR SUPPORT EQUIPMENT — Includes equipment required to support a particular weapon system which is not identified in a specific category.

98 TACTICAL SUPPORT EQUIPMENT — Includes the test and check equipment required to maintain a communications and command control system for supporting various airborne ASW platforms through combinations of communications, recording playback and analysis equipment.

4. REQUIREMENTS.

4.1 General. Work unit codes (WUC) shall be developed in functional system breakdown order and in accordance with the repairability aspect of assigned maintenance functions. A functional system shall be a composite of subsystems, assemblies, or components which are capable of performing and/or supporting an operational role. The repairability aspect of assigned maintenance functions shall be determined by the applicable source codes given in NAVSUP Instruction 4423.14.

4.2 WUC Assignment. A WUC is normally assigned to every repairable item. Five digit codes are assigned to those items which will normally be removed, replaced, tested, adjusted or repaired by maintenance personnel while performing "on-equipment" work i.e., work at or on the weapon which does not require the use of shop equipment other than portable type test or repair equipment. Sixth and seventh digit codes are assigned to repairable component subassemblies modules/ units, cards and significant parts in order to facilitate the reporting of "in-shop" component repair work.

Note

Codes may be assigned to throw-away components and nonrepairable time change items if they are mission essential and require on equipment servicing/ adjustment to maintain operational reliability of the system.

4.2.1 Weapon Systems and Support Equipment. All weapon systems and support equipment required by the procuring document shall have a WUC number assigned in accordance with the applicable aeronautical requirement(s), specification(s), and standard(s), as well as instructions referred to in paragraph 2.1.

4.2.2 WUC Numbering System. WUC consist of a basic five digit number in addition to a supplemental sixth and seventh digit in accordance with the following:

4.2.2.1 FIRST TWO DIGITS. The first two digits are numeric and identify the types of system and/or equipment. These first two digits are standard code designators and shall not be changed except by a change or revision to this document.

4.2.2.2 THIRD DIGIT. The third digit is numeric for airborne systems (but if required may also be alphabetic) and always alphabetic for support equipment. It identifies items such as entire subsystems, a major group of assemblies, and a basic type of engine model. It also identifies, in conjunction with the fourth digit, a complete electronics set or end item of support equipment.

4.2.2.3 FOURTH DIGIT. The fourth digit is numeric for airborne systems (if required, however, may also be alphabetic) and always alphabetic for support equipment. It identifies items such as a complete electronics set (AN/ARN-21, AN/ARC-27, AN/APS-38), an entire support equipment set (AN/APM-200, AN/ASM-499, AN/USM-247), a specific group of components, parts (mechanical, hydraulic, electrical, electronic) or engine sections.

4.2.2.4 FIFTH DIGIT. The fifth digit is used to indicate individual components associated with the "on-equipment" phase of maintenance work. The number nine, used in the fifth digit position, indicates "Not Otherwise Coded." It is the last entry in each sequence of five digit WUC.

Note

The "Not Otherwise Coded" category is used for reporting occasional or recurring discrepancies on non-coded items and may indicate the need for specific codes of these items.

4.2.2.5 SIXTH DIGIT. The sixth digit is numeric, in addition to being alphabetic if necessary, and specifies a repairable subassembly, or parts group, a module or unit of a "black box." When possible, these items should be identified by reference designators for example 1A1, 1A2. The sixth digit is, moreover, associated with "in-shop" code numbers.

4.2.2.6 SEVENTH DIGIT. The seventh digit is numeric, as well as alphabetic if required, and used to identify repairable electronic module subassemblies or cards etc. Whenever possible, these items should be identified by reference designators such as 1A1A1, 1A1A2, 1A1A3. Seven digit numbers are the lowest order of repairable items.

4.2.3 Detailed Assignment Instructions.

1. Zero "0" is never used between other digits in the WUC to form numbers such as 13001, 13020, 13102, 1311201.

2. Alphabetic characters A through Z, except for I and O, are used to augment numbers when coding 3rd, 4th, 5th, 6th, and 7th digits. At all times, numeric characters are used first in

order to complete WUC listings of airborne systems. To complete listings of support equipment, alpha characters are always employed in the third and fourth digits.

3. The fifth digit "9," which designates "Not Otherwise Coded" is always included at the end of each complete FIVE DIGIT item group listing. When a list is long enough to require use of letters in the fifth digit position, the "9" shall be listed after the last letter code. In those instances where the coding assignment for fifth level items exceeds eight numerals plus twenty-four letters, a statement shall be inserted prior to the "9" digit in order to identify the system and the newly designated fourth level block. For example, 74240 *would be used to list items* 74241 through 7424Z. Subsequent to 7424Z and prior to 74249, a statement would be inserted to read that the AN/APG59 is continued in 74250. Similarly, another statement prior to 74250 would read that the AN/APG59 is continued from 74240.

Note

The "Not Otherwise Coded" designation shall not be used for 6th and 7th digit component breakdown listings.

4. When a singular component functionally serves two or more systems or subsystems, only one WUC is assigned to the component. This WUC shall appear in one of the systems' listings. The component, however, shall be tabulated by identical nomenclature designation only in the *remaining* applicable systems listings with a reference to the previously assigned WUC i.e., "Nomenclature (Ref. 71114)." Five dashes (– – – – – –) shall be used in the code column for components referenced in this manner. Also, when a multifunctional component is assigned a seven digit breakdown for "in-shop" work reporting, the sixth and seventh digit breakdown shall appear in the "referenced" listing only.

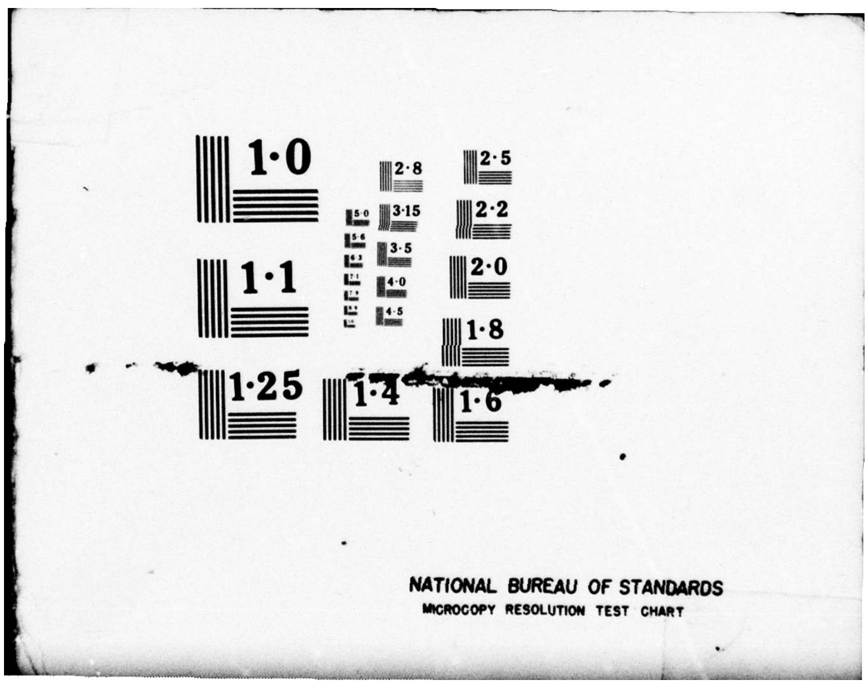
5. All WUC do not require use of the sixth and seventh digits. Consequently, these digits are employed exclusively in those instances when it is necessary to further breakdown a component or "black box" into its repairable subassemblies, modules, and parts. When this breakdown is used, the complete component is identified with the basic five digit number or code plus two "zeroes" in the sixth and seventh positions (XXXXX00). Components and items which do not require further breakdown for "in-shop" work reporting shall employ five digits only.

6. The nomenclatures employed when assigning WUC are consistent with the nomenclatures located in the title block of drawings which have been officially assigned in accordance with MIL STDs 196 and 875. WUC nomenclatures shall be abbreviated in accordance with MIL-STD-12. WUC undergoing preparation on weapons and ground support equipment systems for which maintenance and illustrated parts breakdown technical publications have been delivered shall use nomenclatures employed in these publications.

7. The security classification of WUC is unclassified. In some instances, compliance with this security requirement may necessitate minor changes to the descriptive nomenclature.

AD-A053 486 INSTITUTE FOR DEFENSE ANALYSES ARLINGTON VA COST ANAL--ETC F/G 15/5
THE FEASIBILITY OF ESTIMATING AVIONICS SUPPORT COSTS EARLY IN T--ETC(U)
SEP 77 J D MORGAN, A B FULLER DAHC15-73-C-0200
UNCLASSIFIED P-1292-VOL-2 IDA/HQ-77-19783 NL

2 OF 3
ADA
053486


1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
1·1
4·5
1·8
1·25
1·4
1·6
NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

8. Avionics systems and avionics support equipment WUC are assigned to those systems and sets having approved military nomenclature and/or identification assigned i.e. AN/ARN52(V), A/A37B1. For those equipments which do not have an approved military nomenclature and/or identification, assignment of WUC shall be delayed until identification is resolved.

4.2.4 Component Assignment. Components requiring Accessory Record Cards will be assigned WUC. For multiple installation of items in the same system such as power plants for example, there is only one coding breakout. This applies to "left" and "right" items, a main landing gear, and wing tips all of which are merely "mirror images." It also applies to avionics component subparts such as modules and cards, which are installed in multiples but because they do not have individual reference designators are actually one item only.

4.2.5 Additional Assignment Information. WUC are intended for functional identification and will not normally be applied to locations or general terms. However, terms such as forward fuselage, main landing gear, and air conditioning may be used to identify subsystems in the technical publications manual. Although a WUC is implied in these instances, it should not be assigned.

4.3 WUC NUMBERING STRUCTURE. The following paragraphs contain examples of how and detailed instructions for using individual digits in the WUC numbering structure for avionics systems and trainers, power plants, air vehicle systems and trainers, and support equipment systems. Coding for many of these systems is standardized and maintained in the master work unit code file by NAVAIRTECHSERVFAC.

4.3.1 AVIONICS SYSTEMS AND TRAINERS. Avionics and trainer weapon systems are located in the 52000-79000, 87000-89000, and 99000 code series. The figure below shows the WUC numbering structure and illustrates how the individual digits are used for coding these systems.

76 21 5 32

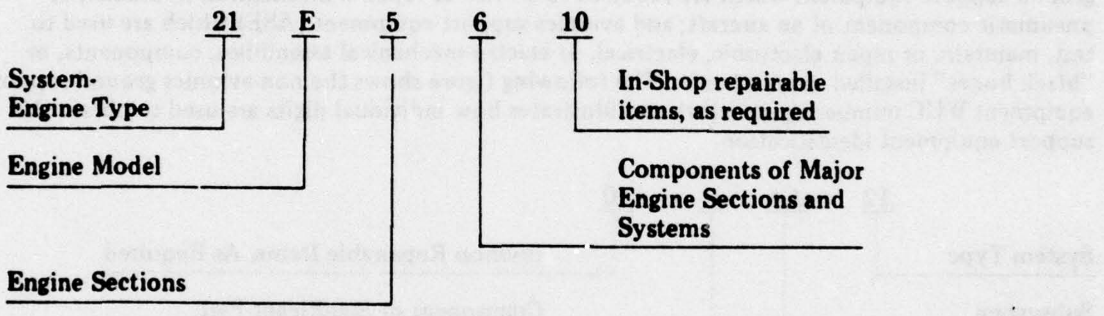
Digits	Meaning
76	System Type Identification
21	Set Identification
5	Component "on-equipment" Identification i.e. wra's or black boxes
32	Further breakdown of components as required. Normally "in-shop" repair items such as sra's and sub-sra's

The first two digits are numeric and provide system type identification such as flight reference, hf communications, electronic countermeasures, etc. Third and fourth digits are numeric/alpha and designate a complete avionics set i.e., AN/ARN-21, AN/ARC-27, AN/ASB-12.

The fifth digit is either numeric or alpha and identifies components which cannot be further disassembled without requiring aid of shop facilities. The fifth digit is the "black box" level which when removed and replaced is defined as "on-equipment" maintenance work. Sequencing is accomplished by using numbers 1 through 8 followed by alpha A through Z, but excluding I and O, and completed by number 9 which denotes "not otherwise coded."

Sixth and seventh digits are numeric 1 through 8 followed by alphabetical A through Z except for letters I and O. These digits designate further breakdown of components. Equipment identified with this level is associated with "in-shop" maintenance work. Fifth, sixth, and seventh digit sequencing also applies to power plant, air vehicle systems and trainers.

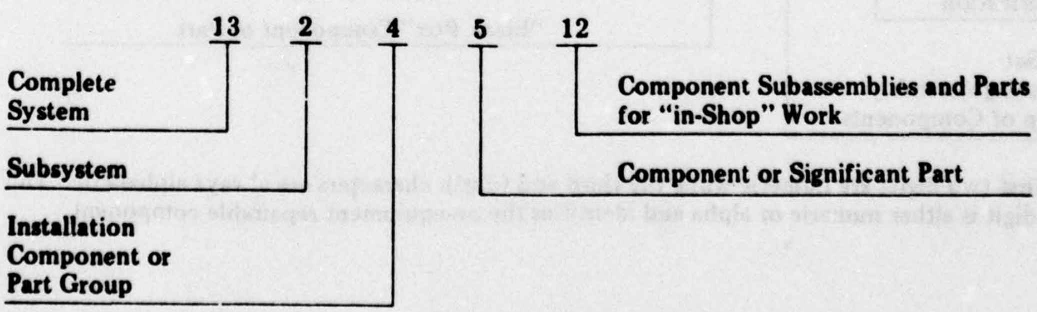
4.3.2 <u>POWER PLANT SYSTEMS</u>. These systems are located in the 21000 through 25000, and 27000 code series. However, helicopter vtol and stol power transmission code series 26000 and power plant installation code series 29000 are coded in accordance with the method established for air vehicle systems and trainers. (Refer to paragraph 4.3.3.) The following illustration depicts power plant WUC numbering structure and shows how individual digits are used to obtain basic engine identification.



The first two digits are numeric and used to identify types of engines such as reciprocating, turboprop, turbojet, and turbofan. Third and fourth digits are either numeric or alpha and designate engine model and section, respectively. Just as for avionics equipment, the fifth digit either numeric or alpha specifies the on-equipment repairable component.

All engines are assigned codes to the seventh digit. Missile propulsion systems code series 25000, however, is coded to the fourth position only because practical application of these items is limited.

4.3.3 <u>AIR VEHICLE SYSTEMS AND TRAINERS</u>. Air vehicle systems and trainers are coded in the 11000-19000, 26000, 29000-51000, 81000-85000, and 91000-97000 weapon system series. The illustration below shows WUC numbering structure for air vehicle systems and trainers and illustrates how employ of these individual digits identifies each system respectively:



The first two digits are numeric and provide system identification. Remaining digits are either numeric or alpha. If, for airborne equipment, an alpha character is used in the third position, it will always be followed by a numeric character in the fourth position. This distinguishes between airborne and ground support equipment since the latter employs alpha characters in the third and fourth positions.

4.3.4 SUPPORT EQUIPMENT. Support equipment system codes are located in the 11000-98000 support equipment series. There are two categories of support equipment: non-avionics ground support equipment which are required to service or repair a mechanical, hydraulic, or pneumatic component of an aircraft; and avionics support equipment (ASE) which are used to test, maintain, or repair electronic, electrical, or electro-mechanical assemblies, components, or "black boxes" installed in an aircraft. The following figure shows the non-avionics ground support equipment WUC numbering structure and illustrates how individual digits are used to obtain this support equipment identification.

12 AA 5 10

- 12 — System Type
- AA — Subsystem GSE Item
- 5 — Component or Significant Part
- 10 — In-Shop Repairable Items, As Required

The first two digits are numeric and provide identification of the type of systems being supported such as flight reference test and check equipment, communications test and check equipment, weapon control test and check equipment. Third and fourth digits are always alpha and identify a complete test set, operating assembly, or item of ground support equipment. The characters for these third and fourth digits run consecutively within a system from "AA to ZZ" in order to aid identifying specific equipments. The fifth digit is either numeric or alpha and identifies the on-equipment repairable component. The WUC numbering structure shown below illustrates use of individual digits for ASE identification.

73 DB 6 12

- 73 — System Type Identification
- DB — Test Set Operating Assembly Group of Components
- 6 — "Black Box" Component or Part
- 12 — "In-Shop" Repairable Modules and Boards

The first two digits are numeric while the third and fourth characters are always alphabetic. The fifth digit is either numeric or alpha and identifies the on-equipment repairable component.

4.3.5 AVIONICS SYSTEMS AND TRAINERS EXAMPLES.

CODES	DESCRIPTION
63000	UHF COMMUNICATIONS SYSTEM
63340	AN/ARR69 RADIO RECEIVING SET
6334100	R1286/ARR69 Receiver
6334110	IF/AR Module
6334120	Rf Module
6334130	Preselector
6334140	Main Chassis
63343	MT3590/ARR69 Mount
63345	MT3137/ARR69 Elec Eqpt Shock Mt. Base
63349	NOC

Note

The above is straightforward example of a five digit numeric (on-equipment) code application. It also shows sixth and seventh numeric (in-shop) identification codes. For detailed explanations of fifth, sixth, and seventh digit numeric codes refer to paragraph 4.3.1. Because the above list is complete, code number 63349 is placed in the Work Unit Code column to indicate "Not Otherwise Coded."

CODES	DESCRIPTION
65000	IFF SYSTEMS
65340	AN/APX72 TRANSPONDER SET
6534100	RT850( )/APX72 Receiver Transmitter
6534110	Rf Section Assembly
6534111	Diplexer
6534112	Modulator A7
6534113	Sensitivity A8
6534116	Detector/Video Amplifier AR3
6534119	Low Pass Filter Z3
65341AO	Processor A1
65341BO	Decoder A2
65341CO	Mode 4 A3
65341DO	Encoder Clock A4
65341EO	Encoder Control A5
65341FO	Encoder Grating A6
65341GO	Delay Line DL1
65341HO	Power Supply PS1
65346	MT3809/APX72 Mount
-----	TS1843 ( ) APX (Ref. 65Y1Q00)

CODES	DESCRIPTION
----	AS2628/A (Ref. 63Y2E)
----	C6280 ( ) (P) /APX (Ref. 65Y1P00)
----	KIT 1A/TSEC (Ref. 65Y1W)
----	MT3949A/U (Ref. 65Y1X)
----	SA1769/ARF (Ref. 65Y25)
----	IFF Transponder APX72 Wrg (Ref. 428RF)
----	Altitude Sensor Switch (Ref. 12125)
65349	NOC

Note

The above is an example of the fifth level digit "black box" level described in paragraph 4.3.1. Also shown are the use of reference designators in the sixth and seventh digits given in paragraphs 4.2.2.5 and 4.2.2.6, respectively. An example of reference items described in step 4 of paragraph 4.2.3 is also provided.

4.3.6 POWER PLANT SYSTEMS EXAMPLE.

CODES	DESCRIPTION
27000	TURBOFAN ENGINES
27200	F402RR ENGINE
27210	Low Pressure Compressor Section
2721100	Low Press Cprsr Rotor
2721110	1st Stage Module
2721120	2nd Stage Module
2721130	3rd Stage Module
2721200	Low Press Cprsr Case
2721210	Case Unit
27220	Combustion Section
27221	Combustion Chamber Inner Case Assembly
27222	Combustion Chamber
27223	Bulkhead Assembly
27230	Turbine Assembly
27231	Turbine Case
27233	Turbine Exhaust Diffuser Assembly
2723400	Low Pressure Turbine Rotor
2723410	1st Stage Module
2723420	2nd Stage Module
2723500	High Pressure Turbine Rotor
2723510	1st Stage Module
2723520	2nd Stage Module
27236	Stator Support Cone

CODES	DESCRIPTION
27237	Low Pressure Drive Shaft
27238	Engine Insulated Shield
27239	NOC
27240 etc	Exhaust Section
27250 etc	Accessory Gearbox Drive Section

4.3.7 AIR VEHICLE SYSTEMS AND TRAINERS EXAMPLES.

Example 1

CODES	DESCRIPTION
14000	FLIGHT CONTROLS
14110	COCKPIT AILERON/ELEVATOR CONTROLS
1411100	Control Column Assembly
1411110	Control Column Wheel Assembly
1411120	External Tube Control Column Yoke Assembly
1411130	Forward Carriage
1411140	Forward Support
14112	Elevator Torque Tube Assembly
14113	Control Column Elevator Crank Assembly
14114	Control Column Elevator Support Assembly
14115	Elevator Bob Weight Balance Bungee Assembly
14116	Cockpit Control Aileron Trim Tab Actuator
14120	Cockpit Rudder Controls
14121	Primary Support Assembly
14122	Rudder Pedal Adjustment Torque Tube
14123	Forward Rudder Pedal Crank Assembly
14124	Cockpit Controls Pulley Assembly
14125	Lower Rudder Trim Tab Actuator
14126	Rudder Pedal Adjustment Bungee
14129	NOC

4.3.8 SUPPORT EQUIPMENT EXAMPLES.

Example 1

CODES	DESCRIPTION
34000	ENGINE TEST EQUIPMENT
34HCO	JETCAL ANALYZER BH109C/D
34HC100	Deck Assembly
34HC110	Autotak Unit
34HC111	Rear Printed Circuit Board
34HC112	Front Printed Circuit Board
34HC120	Autotemp Unit
34HC121	Printed Circuit Board
34HC130	Resistance Checkswitch
34HC140	Probe Control Module
34HC150	Calibration Module
34HC160	60CPS Protection Module
34HC200	Probe Case
34HC210	Heater Cable
34HC220	Check Cable
34HC230	Power Cable
34HC240	Instrument Cable
34HC250	RPM Check Adapter
34HC260	EGT Indicator Adapter
34HC270	Resistance Check Adapter
34HC280	Insulation Check Adapter
34HC290	Check Cable Adapter
34HC2AO	Switch Box
34HC2BO	Junction Box
34HC2CO	Power Cable Adapter
34HC9	NOC

Note

The above example is an illustration of how non-avionics ground support equipment is coded. For specific details refer to paragraph 4.3.4.

Example 2

CODES	DESCRIPTION
74000	WEAPONS CONTROL AND TEST EQUIPMENT

CODES	DESCRIPTION
74KGO	POWER SUPPLY TEST STATION 649995-1
74KG100	Test Station Subassembly
74KG110	Test Panel 6A1
74KG120	Power Supply Subassembly 6A2
74KG130	Power Distribution Panel 6A3
----	Power Supply 6438B (Ref. 79JB4)
----	Power Supply 6205B (Ref. 79JB6)
----	Digital Vm 3440A (Ref. 79EA4)
----	Range Unit 3445A (Ref. 79EC5)
----	Oscilloscope R564B (Ref. 79FCG)
----	Vertical Plug In 3A6 (Ref. 79FCY)
----	Time Base Plug In 3B3 (Ref. 79FCZ)
----	Counter 5325B (Ref. 79HBD)
----	Multimeter 630 ( ) (Ref. 79EDS)
----	Probe 010-0185-00 (Ref. 79CB6)
74KG9	NOC

Note

The above is a typical example of an ASE WUC breakdown. Paragraph 4.3.4 provides complete ASE coding details.

APPENDIX C

COMPARABILITY ANALYSES IN THE LOGISTICS COMPOSITE (LCOM) MODEL

COMPARABILITY ANALYSES IN THE LOGISTICS COMPOSITE (LCOM) MODEL

The LCOM model is a simulation model that can accept reliability and maintainability data for a real or proposed aircraft, fly the aircraft within specified operational and maintenance environments, and output the maintenance manpower required to service the aircraft at a base. In order to construct the reliability and maintainability characteristics of an F-X aircraft and its components, including avionics, the LCOM process has adopted an analogy to existing systems approach based on expert engineering judgements. Under this analogy approach, called "comparability analysis," a set of experts identifies existing operational aircraft components that are the best analogies to proposed components on the F-X aircraft. Once the best analogy equipments are identified, their reliability and maintainability characteristics, developed from Air Force data systems, are adjusted to reflect improvements or degradations expected on the new F-X components.

The Crew Station, Escape and Human Factors Branch, of Aeronautical Systems Division at Wright-Patterson AFB is the primary office of responsibility for LCOM policy and procedures, and this office has produced a sample presentation detailing how the comparability analysis procedure works. Their presentation is reproduced in this appendix.

Comparable Item Approach to Establishing Frequency of Maintenance and Maintenance Tasks for a New Aircraft.

1. **THE PROBLEM:**

It is difficult enough to determine the average rates of maintenance actions that will be done on an aircraft that we have been flying for several years. Although the equipment design is established, the kinds of missions to be flown, climatic conditions, experience of pilots and maintenance personnel, level of spares on hand, command and local maintenance practices, and other unknown and transient factors impact how much work is done and reported on any given item in a specific time period. It is even more difficult to accurately predict "mature" maintenance rates for new aircraft that have not yet had extensive operational use.

One approach is to use failure rates required by specifications or demonstrated in reliability tests. The improvement curves for reliability as a function of testing and correction are well established. The trouble is that maintenance work occurs in the field 5 to 10 times as frequently as the "true" failures that are demonstrated on carefully built equipment under more ideal test conditions, and the factor cannot be predicted with consistency. Initial testing at Edwards Air Force Base and during OT&E does not provide a large enough statistical data base by itself, and is confounded by design changes and deficiencies which are being corrected.

An alternative approach is to identify a comparable piece of equipment that is already in use for a similar purpose in a similar physical and operational environment, and use field experience on it as a baseline for predicting maintenance frequency on the new equipment. This assumes that many of the unmeasurable factors will affect both items in a similar way, and that any design goofs on the new equipment will be corrected during test.

The objective of comparability analysis is to establish the rate at which corrective maintenance will be done, analagous to failure rate. Other maintainability factors (time, crew size, accessibility, AGE needed) may also be assessed, but are strictly secondary considerations in identifying comparability.

2. LEVEL OF DETAIL:

Comparability identification must be done in a way that allows access to field reported data on the comparable item. Air Force maintenance work is reported against work unit codes (WUC) so the identification must be in these terms. The WUC is a five digit number. The first two digits represent an aircraft functional "system", such as propulsion, pneudraulics system, landing gear system, and fire control system. The third digit represents a further subsystem functional breakout, such as nose landing gear or fire control radar. The fourth and fifth digits represent line (LRU) or shop (SRU) replaceable units, such as hydraulic pumps, actuators, control panels, circuit cards, etc. There are also work unit codes with a "9" in the fifth position that represent all the lines, wiring, and miscellaneous parts that are not otherwise coded.

The first level of comparability that must be assessed is the subsystem. Every 3 digit level code on the new system should be paired with some 3 digit code(s) on existing systems. This is because troubleshooting, functional checks, adjustments, "cannot duplicate" work, and many minor repair jobs are usually reported at this level. If only component comparabilities were considered, this workload would be missed. In some cases there is absolutely nothing similar at 3 digit level, and the subsystem estimate must be built up from comparable LRU's. Extra care must then be taken to also include comparability for each type of subsystem level work mentioned above.

Within each subsystem, comparable items must also be identified for significant LRU's at 4 or 5 digit level. What is significant varies with the application, but is determined with respect to frequency of replacement, cost if the item is carried in supply, use of shop AGE, and expected repair time. This level of information and configuration detail are not normally defined until the aircraft has completed design reviews during the development phase. Earlier analyses are generally limited to a 3 digit level of detail that is useful for preliminary manning predictions, but not for estimating AGE or spares requirements.

3. DIMENSIONS OF COMPARABILITY:

The most frequently asked question when someone is asked to name a comparable subsystem is "comparable in what way?". Unfortunately, that question does not have a definite answer. The critical variables for comparable maintenance frequency differ by subsystem and have not been adequately investigated. We do not even know what are the most relevant ways to measure failures. Guns may fail in proportion to rounds fired, tires in proportion to landings, and starters in proportion to start cycles, but many kinds of gear seem to fail on some combination of cycles and duration of use. It is precisely because we don't know what to look at to establish comparability that we rely on the expert judgement of the engineers and maintenance specialists familiar with a given type of equipment. The objective is to identify existing equipment that can be used as a baseline to predict frequency of maintenance on new equipment. The specialist must draw on years of practical experience and technical knowledge to know what are the most important considerations in making this determination. The following checklist is provided as a guide:

a. <u>Establish the measurement base:</u>

Is maintenance frequency driven by the number of sorties, operating hours, flying hours, cycles, or what? If there is nothing better, use sorties as the common base. How does utilization of the planned equipment compare with utilization of similar gear on other aircraft?

b. <u>Equipment function:</u>

What does it do, and what serves a similar purpose on other aircraft? How do key performance requirements compare?

c. <u>Design:</u>

How complex is it, how big is it, at what rates and states does it operate? What is it made of and how does it work?

d. <u>Quantity:</u>

How many are there on the proposed aircraft, and how many on the comparable aircraft? (the number does not usually affect selection of a comparable item, but must be known to correctly interpret maintenance data from the field).

e. <u>Operating environment:</u>

Under what conditions does it operate when installed? In what ways is it used (e.g., in the air, on the ground, in a pressurized cabin, subject to gun vibration, contamination, corrosion)?

f. Maintenance environment:

What command uses it, and who maintains it? How much preventative maintenance and/or inspection is done? (Maintenance rates on the same equipment vary by command).

4. ESTABLISHING ADJUSTMENT FACTORS:

There is seldom a perfect match between two pieces of equipment on all the characteristics that could impact frequency of corrective maintenance. The expert who identifies a comparable item must also develop some arithmetic factors which can be applied to the field data to adjust for differences between the new and the comparable equipment. The factor on maintenance rate should be expressed as a decimal. A number less than one means the new equipment will require corrective maintenance less often, and greater than one more often, than the comparable item.

For example, suppose starts was identified as the measurement base. If the new starter is expected to be twice as good in the field as the starter identified as comparable, a .5 factor would be indicated. The maintenance model for the new aircraft would show half as many starter maintenance actions per start as the comparable starter had experienced.

Once the comparable item and maintenance frequency factor are determined, then any major differences in maintenance methods, task times, and crew sizes may also be assessed. These differences may be expressed as a numeric and/or described in narrative, but should be identified to access, troubleshoot, replacement, checkout or shop checkout and repair tasks. Significant differences in AGE required or in scheduled inspection/service requirements should also be annotated, where known.

5. EXCEPTIONS:

A few subsystems will be so different, or incorporate such new state of the art, that no comparable equipment can be identified. In these cases the estimated maintenance frequency must be built-up or factored from reliability demonstration data, with careful attention to all the considerations listed in paragraph (3) above.

Engines are an exception in that lower indenture comparability is not very useful. The engine operates as an entity, and comparability must be assessed for a whole engine. If that is not possible, the task estimates must be built-up, starting with an estimate of the premature removal rate. However, the engine accessories and engine mounted equipment are conveniently handled by comparability procedures.

COMPARABILITY STUDY FORMAT

1. Equipment and WUC:

2. Number Installed:

3. Comparable Equipment, A/C, and WUC:

4. Number Installed:

5. Measurement Base:

6. Duty Cycle per Sortie, if other than sortie base:

7. Reliability Factor:

8. Rationale:

9. Maintainability Factors and/or Discussion: *

10. Other Significant Differences (AGE, Scheduled Maintenance, etc.) *

11. Prepared by:

* Where Known

SAMPLE CONSIDERATIONS FROM PREVIOUS STUDIES

AIRFRAME:	Empty weight, square foot area, stressed or non-stressed construction, materials (e.g., use of composites). Number and type of doors, access panels, and windows, relative numbers and type of fastners, expected "G" loading, speed and cycling under various mission profiles. Airframe should be treated at the broadest level of indenture possible.
COCKPIT:	Windshield/canopy material and area, type of ejection/escape system.
LANDING GEAR:	Landing weight and speed, number, ply, and size of tires, wheel loading, brake material, idle thrust and taxi speed, methods of retraction, steering, control.
FLIGHT CONTROLS:	How powered, extent of automatic and electronic control, size and kinds of control surfaces, A/C maximum speed.
PROPULSION:	Type of engine, by pass ratio, number and kind of stages, size and maximum thrust, cycling under various mission profiles, materials and operating temperatures, on-condition instrumentation, type of starting. The basic engine should be considered as an entity when assessing comparability.
AIR CONDITIONING/HEATING:	Method of heating/cooling, type of heat exchanging, size of cabin, crew, amount of avionics to be cooled, operation on the ground, manufacturer.
ELECTRICAL AND LIGHTING:	CSD manufacture, how generator driven, KVA, voltage, phase/frequency, generator RPM, capacity of transformers/inverters, type of battery, extent and type of wiring.
PNEUDRAULICS:	Number and capacity of pumps, how pumps driven, system redundancy, operating pressures, type of tubing.
FUEL SYSTEM:	Number and size of integral bladder tanks; tank sealant; number, type, and location of pumps, valves and probes; pump capacities and power

source; system feed mechanism and operating pressure; fueling points.

INSTRUMENTS: Comparison of individual instruments by function, type sensor, type readout.

AVIONICS: Function, parts count, operating power, complexity, interconnects and multiplexing, cooling and pressurization, vibration number and type of rotating electro-mechanical components, solid state vs. tube, number of connectors and operator controls, number and type of signals displayed.

<u>**NOTE:**</u> Techniques exist for assessment of avionics specification/demonstration reliability by build-up techniques and/or statistical regression. These techniques utilize parts counts, complexity factors, and/or component reliability data. They may be useful in establishing the adjustment factor due to design differences between new and comparable equipment.

EXAMPLE OF SUBSYSTEM LEVEL COMPARABILITY WRITE UP FOR A-10

1. Hydraulic Systems PC1 and PC2
   WUC 45A00
   WUC 45F00 (Indicating Systems)

2. (1)

3. A7D Hydraulic Systems PC1 and PC2
   WUC 45A00 and 45B00

4. (1)

5. Per Sortie Base

6. N/A

7. Reliability Factor: .75

8. Rationale:

The A-10 hydraulic system is similar to the A-7 in that both aircraft are subsonic and use the same size and speed hydraulic pump. The A-10 however is a dual engine aircraft giving the hydraulic system an inherent dual source of power which provides for greater reliability. The A-7 has been plagued with hydraulic overheat problems due to high pump heat rejection and lack of proper system cooling. Both of these problems have been addressed in the A-10 which should result in increased reliability. The A-7 uses permanent brazed hydraulic fittings internal to the wing fuel tank. The A-10 will employ permanent swaged fittings where possible throughout the aircraft and permanent ends on detachable fittings where a detachable fitting is required. This will give the reliability of A-7 permanent joint concept distributed over the entire A-10 aircraft and represents a system that is lower in initial cost and easier and simpler to maintain. Use of modual packaging to a great extent also increased maintenance and reliability of the A-10 over the A-7. Based on the above, the A-10 is considered to have a .75 reliability factor over the A-7.

9. Maintainability:

The A-10 has accessible maintenance access in service areas and in troughs along the fuselage. This would rate a .75 on A/C maintenance factor in comparison to the A-7. However, due to inclusion of rigid foam in the trough area, the figure should be revised upward to at least equal (1) of the A-7. Due to design of modular components and plug-in packages, the off-aircraft maintenance should be .9 that of the A-7.

10. **Other Considerations: None**

11. **ENGINEER(S) RESPONSIBLE FOR COMPARABLE SUBSYSTEM DATA:**

APPENDIX D

AIR FORCE OSCER CHART OF ACCOUNTS

AIR FORCE OSCER CHART OF ACCOUNTS

The cost account structure for the Air Force OSCER report is displayed in this appendix.

OSCR

CHART OF ACCOUNTS (AIRCRAFT)
(To be used with suffix coding as needed)

OPERATIONS

1XXX Base-Level Operations

11XX Flying Operations

1110 Aircrew
1115 Unit Administration/Life Support
1120 Operations Staff
1130 Aviation POL

12XX Weapon System Maintenance

1210 Consolidated Maintenance
1220 Organizational Maintenance
1230 Field Maintenance
1240 Avionics Maintenance 6/
1250 Munitions Maintenance
1290 Chief of Maintenance

13XX Base Operations Support (Except RC/CC 5XXX)

1310 Real Property Maintenance Activity (RPMA)
1320 Base Communications
1330 Base Support (housekeeping)

15XX Tactical Air Control, TAC only (future)

SUPPORT

2XXX Depot Operations

21XX Depot Maintenance (IF) - Organic Plus Contractual

2110 Complete Aircraft
2120 Engine Repair
2130 Acft/Engine Accessories & Component Repair
2140 Electronics and Communications Repair
2150 Armament Repair
2160 AGE Repair

22XX Director of Distribution (D/D) - PEC 71111F

23XX Director of Materiel Management (D/MM) - PEC 71112F

24XX Director of Procurement (D/P) - PEC 71113F

25XX ALC Base Operating Support (Except RC/CC 5XXX)

2510 ALC Real Property Maintenance
2520 ALC Base Communications
2530 ALC Base Support (housekeeping)

26XX Second Destination Transportation - PEC 78010F

2610 Via ASIF--Other
2620 Via MSC -- (former MSTS)
2630 Via Commercial Air
2640 Via Commercial Surface CODE
2650 LOGAIR
2660 Port Handling Cost -- MTMTS
2670 Other Transportation Costs--Packing, Crating, Temporary Storage

3XXX Recurring Investments (Appropriations 3010, 3020 and 3080)

31XX Exchangeable Replacement

33XX Common Ground Support Equipment (GSE)

34XX Training Munitions

35XX Modifications

3510 Modification (Class IV and V)
3520 Modification Initial Spares
3530 Component Improvement

4XXX Acquisition and Training Cost by Career Field

41XX Flying Status

411X Officers

4111 Fixed 1/
4112 Variable 2/

412X Enlisted

4121 Fixed 3/
4122 Variable 5/

42XX Non-Flying Status

421X Officers

4211 Fixed 4/
4212 Variable 5/

422X Enlisted

4221 Fixed 3/
4222 Variable 5/

5XXX Other Personnel Support

51XX PCS

5110 Officers
5120 Enlisted

52XX Medical

5210 Officers
5220 Enlisted

1/ Officer acquisition (USAFA, ROTC, OTC, etc); UPT; UNT; Basic Survival Training; Water Survival Training

2/ CCTS

3/ Enlisted Basic Training (Lackland AFB)

4/ Officer Acquisition (USAFA, ROTC, OTS, etc)

5/ Technical School Training at ATC/s Tech Training Centers

OSCR

CHART OF ACCOUNTS
(Suffix coding structure)

.00 No Suffix Coding

.10 Military Labor

- .11 Officers Pay and Allowances (Active Duty)
- .12 Enlisted Pay and Allowances (Active Duty)
- .13 Officers Pay and Allowances (AF Reserve) - MAC Only
- .14 Enlisted Pay and Allowances (AF Reserve) - MAC Only
- .15 Officers Pay and Allowances (ANG)
- .16 Enlisted Pay and Allowances (ANG)
- .17 Officers Pay and Allowances (Military Trainee)
- .18 Enlisted Pay and Allowances (Military Trainee)

.20 Civilian Labor (Includes Direct Hire Local Nationals)

- .21 Civilian Pay and Other Compensation (EEIC 39X except 391)
- .22 Overtime (EEIC 391)

.40 TDY Expense

- .41 AFSF Transportation Expenses (EEIC 407)
- .42 Commercial Transportation Expenses (EEIC 408)
- .43 Per Diem Expenses (EEIC 409)

.50 Supplies, Materiel and Expense Equipment

- .51 Stock Fund Supplies and Materiel Issues (EEIC 60X; $X \neq 1$, 2, or 4)
- .52 Base Procured Supplies and Materiel Issues (EEIC 61X; $X \neq 4$)
- .53 Stock Fund Expense Equipment (EEIC 63X, $X \neq 4$)

.70 Contractual Expenses (AFLC Only)

- .71 Contractual Services (Labor & Material)
- .72 Government Furnished Material (GFM) - Expense
- .73 Other Contract Expenses

.80 Base Command Contractual Expenses (Excluding AFLC)

.90 Other Expenses and Miscellaneous Cost

.91 Administrative - Depot Maintenance (Acct 21XX)
.92 RPM, Other
.93 COMM, Other
.94 Base Operation, Other
.95 Wing/Base Commander, Other
.96 D/D, Other
.97 D/MM, Other
.98 D/P, Other

APPENDIX E

AIR FORCE OSCER REPORT FOR MDS F-15A, FISCAL YEAR 1976

AIR FORCE OSCER REPORT FOR MDS F-15A, FISCAL YEAR 1976

The two pages of formatted operating and support cost data for the F-15A in Figure E-1 represent the standard reporting formats annually published for the MDS aircraft in the Air Force OSCER report.

MDS F015A
POSS ACFT 25.80
FLY HRS 6056
CREW RATIO 1.10

DESCRIPTION	----COST ($ IN MILLIONS)# TOTAL	MAT	CONT	OTHER*	---PAY & ALLOWANCES--- OFF	ENL	CIV	EQUIVALENT WORK LOAD DISTRIBUTION OFF	ENL	CIV
GRAND TOTAL	22.002	5.227	1.103	5.092	2.153	5.654	2.773	96	581	110
MFP - MISSION PE	12.653	4.191		1.173	1.934	4.549	.806	90	482	52
UNIT OPERATIONS	5.533	2.835		.102	1.811	.698	.087	84	74	6
AIRCREW	1.058				1.058			47		
COMMAND	1.805	.165		.102	.753	.698	.087	37	74	6
SECURITY										
POL	2.670	2.670								
BELOW DEPOT MAINTENANCE	6.092	1.356		.043	.123	3.851	.719	6	408	46
CHIEF	.463	.007		.043	.043	.345	.025			
AVIONICS	1.304	.271			.026	.939	.068			
CONSOLIDATED	.029						.029			
FIELD	2.438	.786			.021	1.178	.453			
MUNITIONS/AIRBORNE MISL	.640	.091			.013	.483	.053			
ORGANIZATIONAL	1.218	.201			.020	.906	.091			
SUSTAINING INVESTMENT**	1.028			1.028						
REP SPARES REPLACEMENT	.683			.683						
MOD KITS/MATERIEL										
GSE										
TNG AIRBORNE MISSILE****										
TNG MUNITIONS****	.345			.345						
SAME MFP - SUPPORT PE	3.637	.375	.347	1.005	.120	.929	.861	6	99	58
INSTALLATION SUPPORT	2.884	.375	.347	.252	.120	.929	.861	6	99	58
RPM	1.353	.248	.302	.171	.026	.222	.304			
COMMUNICATIONS	.357	.015	.003	.054	.013	.167	.105			
BASE OPERATIONS	1.174	.112	.042	.027	.081	.540	.372			
ADV TNG (FLYING STATUS)	.753			.753						
OFFICER	.753			.753						
ENLISTED										

* INCLUDES TDY
** COMBAT READY
*** TRAINING AIRCRAFT
**** MAY INCLUDE EXPENDITURES REPORTED UNDER PEC XXX97.
# UNTIL SUCH TIME AS THE COSTS INCLUDED IN THE OTHER COLUMN ARE FURTHER REFINED, ONLY THE TOTAL COLUMN SHOULD BE USED

Figure E-1. OPERATING AND SUPPORT COST ESTIMATING REFERENCE (OSCER) REPORT (REVISED CAIG FORMAT) FISCAL YEAR 1976

MDS F015A
POSS ACFT 25.80
FLY HRS 6056
CREW RATIO 1.10

DESCRIPTION	TOTAL	MAT	CONT	OTHER*	OFF	ENL	CIV
	COST ($ IN MILLIONS)#				---PAY & ALLOWANCES---		
MFP 7	3.671	.622	.723	1.201	.094	.056	1.067
DEPOT MAINTENANCE	3.402	.602	.692	1.120		.033	.955
PDM/MOD	.411	.002	.079	.197		.029	.104
ENGINES	2.637	.530	.448	.868		.003	.788
AVIONICS	.007	.003		.002			.002
OTHER	.347	.067	.165	.053		.001	.061
DEPOT SUPPLY ACTIVITIES	.033			.033			
DISTRIBUTION	.021			.021			
MATERIEL MANAGEMENT	.009			.009			
PROCUREMENT	.003			.003			
TECHNICAL SUPPORT							
SECOND DEST TRANS	.035			.035			
INSTALLATION SUPPORT	.201	.020	.031	.013	.004	.021	.112
RPM	.127	.018	.029	.013	.001	.007	.059
COMMUNICATIONS	.018				.001	.007	.010
BASE OPERATIONS	.056	.002	.002		.002	.007	.043
MFP 8	2.041	.039	.033	1.713	.095	.122	.039
ADVANCED TRAINING	1.075			1.075			
OFFICER	.093			.093			
ENLISTED	.982			.982			
HEALTH CARE	.332	.039	.033	.004	.095	.122	.039
PCS	.634			.634			
INSTALLATION SUPPORT							
RPM							
COMMUNICATIONS							
BASE OPERATIONS							

* INCLUDES TDY
**EXCLUDING TECHNICAL SUPPORT

Figure E-1 (concluded)

APPENDIX F

INCREASE RELIABILITY OF OPERATIONAL SYSTEMS (IROS)

INCREASE RELIABILITY OF OPERATIONAL SYSTEMS (IROS)

The Increase Reliability of Operational Systems (IROS) program is implemented within AFLC to discover disproportionate equipment consumers of logistic resources, and to seek cost-effective improvements. IROS identifies high consumers of logistic costs for the 37 aircraft, 10 aircraft engines, 2 missiles, 91 communications-electronic-meterological equipments, and 16 munitions handling equipments listed below, as of March 1977.

IROS PROGRAM SYSTEMS AND EQUIPMENTS: Following are systems and equipments for which IROS data products are available.

C = Cost Data
A = Availability Data
S = Safety Data
E = System Effectiveness Report

BOMBERS
B-52D C A E
B-52G C A S E
B-52H C A S E
B-57 C A
FB-111A C A S E

CARGO
C-5A C A E
C-9A C A
C-130A C A E
C-130B C A E
C-130E C A E
HC-130H C A E
KC-135A C A E
C-141 C A S E

DRONES
AQM-34 C

FIGHTERS
A-7D C A S E
A-10A C A E
A-37 C A S E
F-4C C A S E
F-4D C A S E
F-4E C A S E

FIGHTERS (Cont'd)
F-15A C A E
F-106 C A S
F-111A C A S E
F-111D C A E
F-111E C A E
F-111F C A E

HELICOPTERS
UH-1F C A
UH-1N C A
CH-3C C A
HH-53C C A

MISSILE
AGM-69 C
LGM-30 E

RECONNAISSANCE
RF-4C C A S E

SPECIAL
OV-10 C A S
O-2 C A S

TRAINERS
T-33A C A E
T-37 C A S E

TRAINERS (Cont'd)
T-38 C A S E
T-39 C A E

RADAR EQUIPMENT
AN/FPN-16 C
AN/FPN-47 C
AN/FPS-6 C
AN/FPS-6A C
AN/FPS-7 C
AN/FPS-26 C
AN-FPS-27A C
AN/FPS-66 C
AN/FPS-90 C
AN/FPS-93A C
AN/FSS-7 C
AN/FYA-71 C
AN/FYQ-9 C
AN/FYQ-42V C
AN/FYQ-47 C
AN/MCC-12 C
AN/MPN-13/13(A-E) C
AN/MPN-14G C
AN/MPN-14H C
AN/MPQ-T2A C
AN/MSC-54 C

RADAR EQUIPMENT (Cont'd)

AN/MSQ-77	C
AN/TSQ-96	C

RADIO EQUIPMENT

AN/GRR-26	C
AN/GRT-18	C
AN/GRT-23	C
AN/MRC-107	C
AN/MRC-108	C
AN/MRC-113	C
AN/TRC-97A	C
AN/TSC-38B	C

407L SYSTEM

AN/TPS-43	C
AN/TPS-44	C
AN/TRC-87	C
AN/TSC-53	C
AN/TSC-60(V)1	C
AN/TSC-60(V)2	C
AN/TSC-60(V)3	C
AN/TSQ-91(V)	C
AN/TSQ-92(V)	C
AN/TSQ-93(V)	C
AN/TTC-30	C

465L SYSTEM

AN/FYQ-3	C
AN/FYQ-4	C
AN/FYQ-5	C
AN/FYQ-6	C
AN/FYQ-7	C
AN/FYQ-8	C
AN/FYQ-18	C
AN/FYQ-23	C
AN/FYQ-26	C
AN/FYQ-26A	C
AN/FYQ-27	C
AN/FYQ-28	C
AN/FYQ-31	C
AN/FYQ-32	C
AN/FYQ-59	C
AN/FYQ-60	C
AN/FYQ-61	C
AN/FYQ-62	C

486L EQUIPMENT

AN/FCC-32	C
AN/FRC-39A	C
AN/FRC-75	C
AN/FRC-96	C
AN/FRC-97	C
AN/FRC-114	C

486L EQUIPMENT (Cont'd)

AN/FRC-125	C
AN/FRC-126	C
AN/FRM-14	C
AN/MRC-85	C
AN/MRC-105(V)	C
AN/MRC-116	C
AN/TRC-144	C
MC-50	C
MW-503A	C
Misc Eqmt	C

487L SYSTEM

AN/FRC-117	C

DEFENSE SUPPORT PROGRAM

AN/FYH-2(V-2)	C
AN/GIC-21	C
AN/GKC-1	C
AN/GSC-28	C
AN/GSC-29	C
AN/GSC-30	C
AN/GSQ-175	C
AN/GYH-3	C
AN/GYH-5	C
AN/GYK-20	C
AN/GYQ-15	C
AN/GYQ-17	C
AN/GYQ-18	C
AN/GYQ-22	C

MUNITIONS HANDLING EQMT

ETU-77AE	C
MF-9	C
MF-9A	C
MHU-12M	C
MHU-33M	C
MHU-83AE	C
MHU-83E	C
MHU-85M	C
MHU-110M	C
MJ-1	C
MJ-1A	C
3010	C
3030	C
4100	C
6200	C
7720500	C

ENGINES

FO100/A-10A	C
JO060/C-140	C
JO060/T-39	C
JO069/T-37	C

ENGINES (Cont'd)

JO085/T-38	C
TO056/C-130	C
TO056/C-130E	C
TO056/HC-130H	C
TF034/A-10A	C
TF039/C-5A	C

APPENDIX G

NAVY LIFE CYCLE COST FACTORS NAMES,
DESCRIPTIONS, DIMENSIONS AND SOURCES

NAVY LIFE CYCLE COST FACTORS NAMES, DESCRIPTIONS, DIMENSIONS AND SOURCES

This appendix contains a listing of the 104 Cost Factors used in the NAVMAT LCC Model. Names, descriptions, and the source of information have been identified for all the cost factors. These major sources are:

(1) Program Management Office (PMO)

(2) Program Manager for Logistics [PM(1)] and subordinate Logistics Managers

(3) Contractor

(4) Analyst.

Name	AD(I)
Description	Acquisition cost of data during Investment in year I. This refers to acquiring, writing, assembling, reformating technical manuals and other documentation not covered during Research & Development phase.
Dimension	$/year
Source	PMO

Name	ADC(I)
Description	Government payments to the contractor for technical and managerial work performed during the Validation phase of the Research & Development in year I.
Dimension	$/year
Source	PMO

Name	ADG(I)
Description	Government expenditures for technical and managerial work performed during the Validation phase of the Research & Development in year I.
Dimension	$/year
Source	PMO

Name	ATU(I)
Description	Acquisition, transportation, and installation costs of training aids and devices to conduct operator, maintenance personnel, and instructor training courses during initial training program in year I.
Dimension	$/year
Source	PM(L)

Name	BY
Description	Base year during/from which all cost adjustments are made.
Dimension	Dimensionless
Source	PMO

Name	CE
Description	Energy consumption cost incurred during the operat of the prime equipment.
Dimension	$/hr/equip
Source	PM(L) & Contractor

Name	CIPE
Description	Installation cost of the prime equipment (If not covered by the acquisition cost). This cost refers the material and services involved in assembling th equipment and complete checkout to assure achieveme of operational status.
Dimension	$/equip
Source	PM(L)

Name	CM
Description	Cost of materials consumed during the operation of t prime equipment.
Dimension	$/hr/equip
Source	PM(L) & contractor

Name	CP
Description	Average cost per page of set-up, reproduction, and distribution of technical manuals.
Dimension	$/page/copy
Source	PM(L)

Name	CS(I)
Description	Software maintenance cost during prime equipment operation in year I.
Dimension	$/year
Source	PM(L)

Name	CSD
Description	Area cost for depot level maintenance space
Dimension	$/sq.ft./year
Source	PM(L)

Name	CSI
Description	Area cost for O/I level maintenance space
Dimension	$/sq.ft./year
Source	PM(L)

Name	CSO
Description	Area cost for Operational space.
Dimension	$/sq.ft./year
Source	PM(L)

Name	CST(K)
Description	Unit cost of the Kth spare/repair item.
Dimension	$/item
Source	PM(L)

Name	CTI
Description	Average cost incurred during instructor training course for personnel pay & allowance, travel, and course fees.
Dimension	$/student
Source	PM(L)

Name	CTM
Description	Average cost incurred during O/I maintenance personnel training course for personnel pay & allowance, travel and course fees.
Dimension	$/student
Source	PM(L)

Name	CTO
Description	Average cost incurred during operating personnel training course for personnel pay & allowance, travel, and course fees.
Dimension	$/student
Source	PM(L)

Name	CTP
Description	Average cost incurred during depot maintenance personnel training course for personnel pay & allowance travel, and course fees.
Dimension	$/student
Sourse	PM(L)

Name	CTPE
Description	Transportation cost of prime equipment from contractors facility to installation site (if not included in acquisition cost). This includes the packaging and transportation of the prime equipment from the contractors facility to the first destination, and then to the second destination (operation site).
Dimension	$/equip
Source	PM(L)

Name	CU
Description	Unit price of the prime equipment. In addition to the prime equipment hardware this cost may include part or all of production support and services costs, and transportation and installation cost of the equipment. (These costs should be identified properly to avoid double counting).
Dimension	$/equip
Source	PMO

Name	DC(K)
Description	Duty cycle of the Kth spare/repair item. Percent of prime equipment operating time.
Dimension	Ratio (Item operating time/Equip. operating time)
Source	PM(L) & Contractor

Name	DCD(I)
Description	Payment by the Government to the Contractor for all the deliverable data acquired during full scale development in year I. The data requirement will normally be selected from the departmental or agency authorized data list. It includes the effort for acquiring, writing, assembling, reformating, production, packaging and shipping Engineering data, Support data, and Management data required by the government.
Dimension	$/year
Source	PMO

Name	DCE(I)
Description	Payments by the Government to the Contractor for the engineering efforts during full scale development in year I. This includes all engineering efforts associated with the equipment design and development. Specifically, the cost of system engineering, and integration, design engineering, design support engineering, and engineering planning costs. It includes the cost of direct labor, material, overhead, and other direct costs incurred during the engineering process.
Dimension	$/year
Source	PMO

Name	DCH(I)
Description	Payments by the Government to the Contractor for the hardware development efforts during full scale development in year I. This includes the fabrication and assembly of full scale development models in support of the engineering design activity. This includes the cost of direct labor, materials and overhead associated with material procurement and handling, tooling and test equipment in support of manufacturing, fabrication, assembly, system integration, and checkout.
Dimension	$/year
Source	PMO

Name	DCPM(I)
Description	Payment by the Government to the Contractor for the Management effort during full scale development in year I. This refers to the costs incurred for planning, organizing, manning, directing, and controlling the technical and administrative activities of the project. This includes the cost of personnel, services, and overhead associated with cost/schedule control, configuration management, data management, contract management, and ILS (Integrated logistic support) management.
Dimension	$/year
Source	PMO

Name	DCS(I)
Description	Payment by the Government to the Contractor for software development effort for the prime equipment during full scale development in year I. This includes the cost of direct labor, material, overhead, and other direct costs associated with the computer software development.
Dimension	$/year
Source	PMO

Name	DCST(I)
Description	Payment by the Government to the Contractor for the development of the Peculiar Support and Test equipment during full scale development in year I. This refers to all costs inclusive of the software costs associated with Peculiar Support & Test equipment.
Dimension	$/year
Source	PMO

Name	DCTE(I)
Description	Payment by the Government to the Contractor Test & Evaluation efforts during full scale development in year I. This refers to the costs which are incurred in support of the government testing (DTE and IOTE) during the full scale development phase of the equipment life cycle. This cost factor may include for example: spares, repair parts, support & test equipment, training, test site activation, facility requirements, and services. Development test and evaluation (DTE) support is designed to determine and/or verify technical performance and safety characteristics of an item, associated tools and test equipment. It includes determination of structural, mechanical, electrical, chemical and other physical properties of the equipment. DTE is generally conducted in contractors facilities. Initial operational test and evaluation (IOTE) support refers to the operational test and evaluation performed during the full scale development prior to the production decision to provide information as to the equipment military use expected operational effectiveness and operational suitability, maintenance concepts, training needs and technical manual suitability. IOTE is generally conducted at Government facilities.
Dimension	$/year
Source	PMO

Name	DGPM(I)
Description	Government project management costs incurred during full scale development in year I. This refers to the technical and administrative planning, organizing, directing, coordinating, controlling, and approval actions designed to accomplish overall program objectives. Examples of these activities are configuration management, cost/schedule management, data management, contract management, and integrated logistic support management.
Dimension	$/year
Source	PMO

Name	DGTA(I)
Description	Government costs for test site activation/deactivation during full scale development Test & Evaluation program in year I. This refers to the costs for test site modification, transportation and installation of the prototype models at the test site, test site operation, restoration and facilities leased or government facilities used during Test & Evaluation program.
Dimension	$/year
Source	PMO

Name	DGTE(I)
Description	Government personnel costs incurred during full scale development Test & Evaluation program for testing and evaluation.
Dimension	$/year
Source	PMO

Name	DGTT(I)
Description	Government costs to train students during full scale development Test & Evaluation program in year I. This refers to the pay & allowance and travel expenses and the course fees and the training facilities provided by the government.
Dimension	$/year
Source	PMO

Name	DR(I)
Description	Annual discount rate for future costs in year I.
Dimension	Ratio
Source	PMO & Analyst

Name	DSC(K)
Description	Discard rate of the Kth spare/repair item.
Dimension	Ratio
Source	PM(L) & Contractor

Name	FDRT
Description	Required stockage time for depot level repairable items at O/I and depot level.
Dimension	Days
Source	PM(L)

Name	FILS
Description	Required stockage time for replenishment spares at O/I level.
Dimension	Days
Source	PM(L)

Name	FIRT
Description	Repair cycle time of repairable items at O/I level.
Dimension	Days
Source	PM(L)

Name	FM
Description	Repair material rate.
Dimension	Ratio - (Repair material cost/Item unit cost)
Source	PM(L)

Name	FMS(I)
Description	Maintenance site construction/preparation costs during Investment period in year I.
Dimension	$/year
Source	PMO

Name	FOS(I)
Description	Operational site construction/preparation costs during Investment period in year I.
Dimension	$/year
Source	PMO

Name	FPST
Description	Procurement lead and safety level stockage time for initial spare & repair parts.
Dimension	Days
Source	PM(L)

Name	FR(I)
Description	Reliability improvement or degradation factor during year I.
Dimension	Dimensionless
Source	PM(L)

Name	IRCON(I)
Description	Annual inflation rate for future costs for construction type of funding during year I.
Dimension	Ratio
Source	Analyst

Name	IROM(I)
Description	Annual inflation rate for future costs of O&M type of funding during year I.
Dimension	Ratio
Source	Analyst

Name	IRPROC(I)
Description	Annual inflation rate for future costs of procurement type of funding during year I.
Dimension	Ratio
Source	Analyst

Name	IRRD(I)
Description	Annual inflation rate for future costs of R&D type of funding during year I.
Dimension	Ratio
Source	Analyst

Name	ISSD(I)
Description	Storage space required for the depot inventory during year I.
Dimension	sq.ft./year
Source	PM(L) & Contractor

Name	ISSI(I)
Description	Storage space required for the O/I inventory during year I.
Dimension	sq.ft./year
Source	PM(L) & Contractor

Name	IYI
Description	Year I during which initial cost occur.
Dimension	Dimensionless
Source	PMO

Name	LO(I)
Description	Desired manning level for operating personnel during year I.
Dimension	Personnel/year
Source	PM(L) & Contractor

Name	LM(I)
Description	Desired manning level for O/I level maintenance personnel during year I.
Dimension	Personnel/year
Source	PM(L) & Contractor

Name	LP(I)
Description	Desired manning level for depot level maintenance personnel during year I.
Dimension	Personnel/year
Source	PM(L) & Contractor

Name	LPM(N)
Description	Preventive maintenance labor time for the Nth type of maintenance action.
Dimension	hrs/action
Source	PM(L) & Contractor

Name	LSD(K)
Description	Depot maintenance labor time to repair the Kth item.
Dimension	hrs/item
Source	PM(L) & Contractor

Name	LSI(K)
Description	O/I maintenance labor time to repair the Kth item.
Dimension	hrs/item
Source	PM(L) & Contractor

Name	LSO(K)
Description	O/I maintenance labor time to remove, replace the Kth item.
Dimension	hrs/item
Source	PM(L) & Contractor

Name	MPM(N)
Description	Material cost for the Nth type of preventive maintenance action.
Dimension	$/action
Source	PM(L) & Contractor

Name	MSSD(I)
Description	Shop space required for depot maintenance during year I.
Dimension	sq.ft./year
Source	PM(L) & Contractor

Name	MSSI(I)
Description	Shop space required for O/I maintenance during year I.
Dimension	sq.ft./year
Source	PM(L) & Contractor

Name	N(I)
Description	Number of equipments in the Navy's inventory system at the end of year I.
Dimension	equip/year
Source	PM(L)

Name	NC(I)
Description	Number of copies of technical data to be distributed and inventoried during year I.
Dimension	copies/year
Source	PM(L)

Name	NK
Description	Total number of spare/repair items in the prime equipment.
Dimension	Dimensionless
Source	PM(L) & Contractor

Name	NM
Description	Number of preventive maintenance types of the prime equipment.
Dimension	Dimensionless
Source	PM(L) & Contractor

Name	NN(I)
Description	Prime equipment annual acceptance schedule. Number of equipments acquired during year I.
Dimension	equip/year
Source	PMO & PM(L)

Name	NOH(I)
Description	Prime equipment overhaul schedule. Number of equipments scheduled to be overhauled during year I.
Dimension	equip/year
Source	PMO & PM(L)

Name	NP
Description	Number of pages per technical manual maintained by Navy.
Dimension	pages/copy
Source	PM(L) & Contractor

Name	NPM(N)
Description	Time between inspections of the Nth type of preventive maintenance action.
Dimension	hrs/action
Source	PM(L) & Contractor

Name	NPO(I)
Description	Prime equipment phase out schedule. Number of equipments scheduled to be phased out during year I.
Dimension	equip/year
Source	PMO & PM(L)

Name	NSNP
Description	Total number of new National Stock Numbers (NSN) to be issued on the prime equipment
Dimension	NSN
Source	PM(L) & Contractor

Name	NSNS
Description	Total number of new National Stock Numbers (NSN) to be issued on the peculiar Support & Test equipments
Dimension	NSN
Source	PM(L) & Contractor

Name	OHL
Description	Prime equipment overhaul maintenance labor time.
Dimension	hrs/equip
Source	PM(L) & Contractor

Name	OHM
Description	Prime equipment overhaul maintenance material cost.
Dimension	$/equip
Source	PM(L) & Contractor

Name	OHT
Description	Prime equipment overhaul maintenance material shipping rate.
Dimension	$/equip
Source	PM(L) & Contractor

Name	OT
Description	Prime equipment annual operating time.
Dimension	hrs/equip/year
Source	PMO

Name	PMG(I)
Description	Government project management costs incurred during the Investment period in year I. This refers to the technical and administrative planning, organizing, directing, coordinating, controlling and approval actions designed to accomplish overall program objectives. Examples of these activities are configuration management, cost/schedule management, data management, contract management, value engineering, quality assurance, and integrated logistic management.
Dimension	$/year
Source	PMO

Name	PO
Description	Number of personnel required to operate a prime equipment.
Dimension	personnel/equip
Source	PM(L)

Name	PSOS
Description	Floor space required for the operation of a prime equipment.
Dimension	sq.ft./equip
Source	PM(L) & Contractor

Name	PSS(I)
Description	Production support and services cost incurred during the Investment period of the life cycle cost. These are the supportive costs incurred during the production of the prime equipment. These costs may include engineering, facilities, production tooling and testing equipment, quality assurance, overhead costs of general and administrative expenses and contract fee. (NOTE: All or a portion of these costs may be included in the prime equipment hardware acquisition cost. If so user should be carefull not to double count the cost).
Dimension	$/year
Source	PMO

Name	PTE(I)
Description	Production Test and Evaluation costs incurred during Investment period in year I. These costs refer to Production Acceptance Test (PATE) and Operation Acceptance Test (OTE). Production Acceptance Tests are conducted on production items produced early in the production run. They are designed to assure that production equipments conform to design specifications and performance requirements when manufactured in accordance with production specifications. Operational tests are conducted by user personnel under the conditions of the operational tactical environment. They are designed to determine the equipment operational effectiveness and validate organization doctrine, tactics, training requirements and logistic support.
Dimension	$/year
Source	PMO

Name	PTI(I)
Description	Number of instructors to receive initial training during year I.
Dimension	student/year
Source	PM(L)

Name	PTM(I)
Description	Number of O/I maintenance personnel to receive initial training during year I.
Dimension	student/year
Source	PM(L)

Name	PTO(I)
Description	Number of Operating personnel to receive initial training during year I.
Dimension	student/year
Source	PM(L)

Name	PTP(I)
Description	Number of depot maintenance personnel to receive initial training during year I.
Dimension	student/year
Source	PM(L)

Name	QTY(K)
Description	Number of quantities of Kth spare/repair item
Dimension	quantity/item
Source	PM(L)

Name	R(K)
Description	Mean Time Between Failures of the Kth spare/repair item.
Dimension	hrs/failure
Source	PM(L)

Name	RAM
Description	Operator and O/I level maintenance personnel attrition rate.
Dimension	ratio
Source	PM(L)

Name	RAP
Description	Depot level maintenance personnel attrition rate.
Dimension	ratio
Source	PM(L)

Name	RDM
Description	Technical data management costs for file maintenance.
Dimension	$/page/year
Source	PM(L)

Name	RIE
Description	Average National Stock Number (NSN) entry cost into the supply system.
Dimension	$/NSN
Source	PM(L)

Name	RIM
Description	Supply support management item retention and field administration cost.
Dimension	$/NSN
Source	PM(L)

Name	RO
Description	Prime equipment operator pay rate.
Dimension	$/hr/man
Source	PM(L)

Name	RPL
Description	Packaging labor cost.
Dimension	$/#
Source	PM(L)

Name	RPM
Description	Packaging material cost.
Dimension	$/#
Source	PM(L)

Name	RSD
Description	Depot maintenance personnel pay rate to repair failed items.
Dimension	$/hr/man
Source	PM(L)

Name	RSL
Description	O/I maintenance personnel pay rate to remove replace or repair failed items.
Dimension	$/hr/man
Source	PM(L)

Name	RSR
Description	Average shipping Cost.
Dimension	$/#
Source	PM(L)

Name	RSS(K)
Description	Fraction of failures repaired at the intermediate maintenance level. This value lies inclusively between "0" and "1". "0" refers to all depot repair and 1 refers to all intermediate depot repair.
Dimension	ratio
Source	PM(L) & Contractor

Name	RW(K)
Description	Ratio of the shipping weight to the unpacked weight of the Kth item.
Dimension	ratio
Source	PM(L) & Contractor

Name	STE(I)
Description	Support & Test equipment acquisition costs incurred during Investment period in year I. This refers to the Support & Test equipments required to maintain and care for the prime equipment while not directly engaged in the performance of its mission. This includes vehicles, equipment and tools used to service transport and hoist, repair, overhaul, assemble, disassemble, test, inspect or otherwise maintain the mission equipment. This also includes the software costs associated with the Support & Test equipment.
Dimension	$/year
Source	PMO

Name	STEM
Description	Support & Test equipment initial support rate. Percent of S&TE acquisition cost
Dimension	ratio
Source	PM(L)

Name	STES
Description	Support & Test equipment recurring support cost.
Dimension	$/Prime Equipment
Source	PM(L)

Name	W(K)
Description	Unpacked weight of the Kth spare/repair item.
Dimension	#/item
Source	PM(L) & Contractor

Name	TERM
Description	Termination cost and/or value of the prime equipment.
Dimension	$/equip
Source	PM(L)

Name	Y
Description	Total number of years covered by the life cycle cost analysis.
Dimension	dimensionless
Source	PMO

APPENDIX H

NAVMAT EQUIPMENT LCC MODEL EQUATIONS

TOTAL LIFE CYCLE COST is equal to the sum of the following basic equations

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RESEARCH AND DEVELOPMENT COSTS

CBS 111000
Contractor payments paid by the government for the equipment development effort during the R&D Validation Phase are

$$\sum_{I=1}^{Y} ADC(I)$$

Where;

I	Designator for a specific project year
Y	Number of years covered by the life cycle cost analysis
ADC(I)	Contractor payments ($/yr)

CBS 112000
Government expenditures for the equipment development effort during the R&D Validation Phase are

$$\sum_{I=1}^{Y} ADG(I)$$

Where
ADG(I) Government expenditures ($/yr)

CBS 121100
Contractor Management costs during full scale development effort are

$$\sum_{I=1}^{Y} DCPM(I)$$

Where
DCPM(I) Contractor Management costs ($/yr)

CBS 121200
Contractor Engineering costs during full scale development effort is

$$\sum_{I=1}^{Y} DCE(I)$$

Where
DCE(I) Contractor Engineering costs ($/yr)

CBS 121300
Contractor prototype hardware development costs during full scale development effort are

$$\sum_{I=1}^{Y} DCH(I)$$

Where
DCH(I) Contractor prototype hardware costs ($/yr)

CBS 121400
Contractor software development costs during full scale development effort are

$$\sum_{I=1}^{Y} DCS(I)$$

Where
DCS(I) Contractor Software development costs ($/yr)

CBS 121500
Contractor development Test & Evaluation costs during full scale development effort is

$$\sum_{I=1}^{Y} DCTE(I)$$

Where
DCTE(I) Contractor development Test & Evaluation costs ($/yr)

CBS 121600
Contractor Documentation costs during full scale development effort are

$$\sum_{I=1}^{Y} DCD(I)$$

Where
DCD(I) Contractor Documentation costs ($/yr)

CBS 121700
Contractor Support & Test equipment development costs during full scale development effort are

$$\sum_{I=1}^{Y} DCST(I)$$

Where
DCST(I) Contractor S&TE development costs ($/yr)

CBS 122100
Government Program Management costs during full scale development effort are

$$\sum_{I=1}^{Y} DGPM(I)$$

Where
DGPM(I)   Program Management costs   ($/yr)

CBS 122210
Training costs incurred by students during Test & Evaluation maintenance program are

$$\sum_{I=1}^{Y} DGTT(I)$$

Where
DGTT(I)   Training costs   ($/yr)

CBS 122220
Test Site activation/deactivation costs incurred by Government during full scale development Test & Evaluation program are

$$\sum_{I=1}^{Y} DGTA(I)$$

Where
DGTA(I)   Test Site activation/deactivation costs   ($/yr)

CBS 122230
Test & Evaluation costs incurred by Government during full scale development Test & Evaluation Program are

$$\sum_{I=1}^{Y} DGTE(I)$$

Where
DGTE(I)   Test & Evaluation personnel costs   ($/yr)

INVESTMENT COSTS

CBS 210000
Government Program Management cost is

$$\sum_{I=1}^{Y} PMG(I)$$

Where
PMG(I) Program Management costs ($/yr)

CBS 221000
Production hardware costs of the Prime Equipment are

$$\sum_{I=1}^{Y} NN(I) * CU$$

Where
NN(I) Prime equipment annual acceptance schedule (equip./yr)
CU Prime equipment procurement price ($/equip.)

CBS 222000
Production Support & Services costs of the prime equipment are

$$\sum_{I=1}^{Y} PSS(I)$$

Where
PSS(I) Production Support & Services costs ($/yr)

CBS 223000
Production Test & Evaluation costs of the prime equipment are

$$\sum_{I=1}^{Y} PTE(I)$$

Where
PTE(I) Production Test & Evaluation costs ($/yr)

CBS 224000

Transportation to installation site expenditures to cover the cost of moving the prime equipment from the contractors facility to the point of installation are

$$\sum_{I=1}^{Y} NN(I) * CTPE$$

Where

NN(I)	Prime equipment annual acceptance schedule	(equip/yr)
CTPE	Transportation costs	($/equip)

CBS 225000

Installation costs for the Prime Equipment are

$$\sum_{I=1}^{Y} NN(I) * CIPE$$

Where

NN(I)	Prime equipment annual acceptance schedule	(equip/yr)
CIPE	Installation costs	($/equip)

CBS 231000

Acquisition costs of Support & Test equipment are

$$\sum_{I=1}^{Y} STE(I)$$

Where

STE(I)	Support & Test equipment acquisition costs	($/yr)

CBS 232110
Acquisition cost of Primary equipment Initial Spares is

$$\sum_{I=1}^{Y} NN(I) * \sum_{K=1}^{NK} OT*DC(K)*QTY(K)*CST(K)*[DSC(K)*(FPST+FILS) + [1-DSC(K)]*[RSS(K)*FIRT+[1-RSS(K)]*FDRT]] / [R(K)*FR(I)*365]$$

Where

NN(I)	Prime equipment annual acceptance schedule (equip/yr)
OT	Prime equipment annual operating time (hrs/equip/year)
DC(K)	Duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
CST(K)	Unit cost of the Kth item ($/item)
DSC(K)	Discard rate of Kth item (ratio)
FPST	Procurement lead & safety stockage time for spares (days)
FILS	Required stockage time at O/I level for spares (days)
RSS(K)	Repair level ratio (ratio)
FIRT	Required stockage time for O/I repairable items (days)
FDRT	Required stockage time for depot repairable items (days)
R(K)	Mean time between failures for Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)
K	Designator for a specific spare/repair item
NK	The number of spare/repair items in an equipment

CBS 232120

Acquisition cost of Support & Test Equipment Initial Spares is

$$\sum_{I=1}^{Y} STE(I) * STEM$$

Where

STE(I)	Support & Test equipment acquisition costs ($/yr)
STEM	Material support rate . Percent of S&TE cost (ratio)

CBS 232200
Introduction of new NSN's (National Stock Number) into the supply system costs are

$$\sum_{I=IYI}^{IYI} (NSNP + NSNS) * RIE$$

Where
NSNP   Number of new NSN's of Primary Equipment (NSN)
NSNS   Number of new NSN's of Support & Test Equipment (NSN)
RIE   Average NSN entry into the supply system cost ($/NSN)

CBS 233100
Facility costs incurred by the Government to construct/prepare the operational sites are

$$\sum_{I=1}^{Y} FOS(I)$$

Where
FOS(I)   Operational site const/prep. costs ($/yr)

CBS 233200
Facility costs incurred by the government to construct/prepare maintenance sites are

$$\sum_{I=1}^{Y} FMS(I)$$

Where
FMS(I)   Maintenance site constr/prep. costs ($/yr)

CBS 234100
Acquisition costs of Technical Data not included in the development costs are

$$\sum_{I=1}^{Y} AD(I)$$

Where
AD(I)   Technical Data Acquisition costs ($/yr)

CBS 234200
Reproduction and Distribution costs of Technical Data are

$$\sum_{I=1}^{Y} NC(I) * NP * CP$$

Where

NC(I)	Number of copies	(copies/yr)
NP	Number of pages in a set of technical data	(pages)
CP	Reproduction and distribution costs	($/page/copy)

CBS 235100
Operating personnel pay, allowance, travel costs, and course fees incurred during the initial operator training course are

$$\sum_{I=1}^{Y} PTO(I) * CTO$$

Where

PTO(I)	Number of students	(students/yr)
CTO	Operating personnel training cost	($/student)

CBS 235200
O/I level maintenance personnel pay, allowance, travel costs, and course fees incurred during the initial training course are

$$\sum_{I=1}^{Y} PTM(I) * CTM$$

Where

PTM(I)	Number of students	(students/yr)
CTM	O/I Maintenance personnel training cost	($/student)

CBS 235300
Depot level maintenance personnel pay, allowance, travel costs, and course fees incurred during the initial training course are

$$\sum_{I=1}^{Y} PTP(I) * CTP$$

Where
PTP(I) Number of students (students/yr)
CTP Depot Maintenance personnel training cost ($/student)

CBS 235400
Instructor training personnel pay, allowance, travel costs, and course fees incurred during the initial training course are

$$\sum_{I=1}^{Y} PTI(I) * CTI$$

Where
PTI(I) Number of students (students/yr)
CTI Instructor training cost ($/student)

CBS 235500
Acquisition and installation costs of training aids of the initial training program are

$$\sum_{I=1}^{Y} ATU(I)$$

Where
ATU(I) Acquisition and installation costs of training aids ($)

OPERATING AND SUPPORT COST

CBS311000

Personnel pay and allowance costs incurred by the equipment operators are

$$\sum_{I=1}^{Y} N(I) * PO * RO * OT$$

Where

N(I)	Prime equipment inventory	(equip/yr)
PO	Number of operators per prime equipment	(operator/equip)
RO	Operator hourly pay rate	($/hr/operator)
OT	Prime Equipment operating time	(hrs/equip/yr)

CBS 312000

Facility space costs for providing necessary operational area for the equipment are

$$\sum_{I=1}^{Y} N(I) * PSOS * CSO$$

Where

N(I)	Prime equipment inventory	(equip/yr)
PSOS	Operational area per prime equipment	(sq.ft./equip)
CSO	Operational area space cost	($/sq.ft./yr)

CBS 313000

Energy cost incurred during the equipment operation is

$$\sum_{I=1}^{Y} N(I) * CE * OT$$

Where

N(I)	Prime equipment inventory	(equip/yr)
CE	Energy cost	($/hrs/equip)
OT	Prime Equipment operating time	(hrs/equip/yr)

CBS 314000
Material costs incurred during the equipment operation are

$$\sum_{I=1}^{Y} N(I) * CM * OT$$

Where

N(I)	Prime equipment inventory (equip/yr)
CM	Material cost ($/hr/equip)
OT	Prime equipment operating time (hrs/equip/yr)

CBS 315000
Software maintenance costs incurred during the equipment operation are

$$\sum_{I=1}^{Y} CS(I)$$

Where

CS(I)	Prime equipment software maintenance costs ($/yr)

CBS 321110
O/I level Corrective Maintenance Labor costs for the detection, isolation, removal and replacement of item failures in the prime equipment are

$$\sum_{I=1}^{Y} N(I) * \sum_{K=1}^{NK} OT*DC(K)*QTY(K)*LSO(K)*RSL / [R(K)*FR(I)]$$

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
DC(K)	Duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
LSO(K)	O/I maintenance time to remove,replace Kth item (hrs/item)
RSL	O/I maintenance personnel pay rate ($/hr)
R(K)	Mean time between failures for Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)

CBS 321120
O/I level Corrective Maintenance Labor costs incurred during the repair of a failed item are

```
  Y        NK
  § N(I) * §   OT*DC(K)*QTY(K)*LSI(K)*RSL*RSS(K)[1-DSC(K)] /
 I=1       K=1
                                        [R(K)*FR(I)]
```

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
DC(K)	Duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
LSI(K)	O/I maintenance time to repair the Kth item (hrs/item)
RSL	O/I maintenance personnel pay rate ($/hr)
RSS(K)	Repair level ratio (ratio)
DSC(K)	Discard rate of Kth item (ratio)
R(K)	Mean time between failures of Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)

CBS 321130
Depot level Corrective Maintenance costs incurred during the repair of a failed item are

```
  Y        NK
  § N(I) * §   OT*DC(K)*QTY(K)*LSD(K)*RSD*[1-RSS(K)]*
 I=1       K=1
                              [1-DSC(K)] / [R(K)*FR(I)]
```

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
DC(K)	Duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
LSD(K)	Depot maintenance time to repair Kth item (hrs/item)
RSD	Depot maintenance personnel pay rate ($/hr)
RSS(K)	Repair level ratio (ratio)
DSC(K)	Discard rate of Kth item (ratio)
R(K)	Mean time between failures of Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)

CBS 321200

Corrective Maintenance Repair Material costs are

```
 Y        NK
 §  N(I)* § OT*DC(K)*QTY(K)*CST(K)*FM*[1-DSC(K)] / [R(K)*FR(I)]
I=1       K=1
```

Where

N(I)	Prime equipment inventory	(equip/yr)
OT	Prime equipment operating time	(hrs/equip/yr)
DC(K)	Duty cycle of Kth item	(ratio)
QTY(K)	Quantity of Kth item	(quantity/item)
CST(K)	Unit cost of the Kth item	($/item)
FM	Repair material rate. Percent of item cost	(ratio)
DSC(K)	Discard rate of Kth item	(ratio)
R(K)	Mean time between failures of Kth item	(hrs/failure)
FR(I)	Reliability improvement/degradation factor	(factor)

CBS 321310

Packaging Labor costs incurred during the process of shipping failed items between the intermediate and depot level maintenance facilities are

```
 Y        NK
 §  N(I)* § OT*DC(K)*QTY(K)*2*W(K)*RPL*[1-RSS(K)] *
I=1       K=1

                        [1-DSC(K)] / [R(K)*FR(I)]
```

Where

N(I)	Prime equipment inventory	(equip/yr)
OT	Prime equipment operating time	(hrs/equip/yr)
DC(K)	Duty cycle of Kth item	(ratio)
QTY(K)	Quantity of Kth item	(quantity/item)
W(K)	Weight of Kth item	(#)
RPL	Packaging labor cost	($/#)
RSS(K)	Repair level ratio	(ratio)
DSC(K)	Discard rate of Kth item	(ratio)
R(K)	Mean time between failures of Kth item	(hrs/failure)
FR(I)	Reliability improvement/degradation factor	(factor)

CBS 321320
Packaging Material cost incurred during the process of shipping failed items between the intermediate and depot level maintenance facilities are

$$\sum_{I=1}^{Y} N(I) * \sum_{K=1}^{NK} OT*DC(K)*QTY(K)*2*W(K)*RPM*[1-RSS(K)] * [1-DSC(K)] / [R(K)*FR(I)]$$

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
DC(K)	Duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
W(K)	Weight of Kth item (#)
RPM	Packaging material cost ($/#)
RSS(K)	Repair level ratio (ratio)
R(K)	Mean time between failures of Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)

CBS 321330
Shipping cost incurred during the transportation of failed items between the intermediate and depot level maintenance facilities are

$$\sum_{I=1}^{Y} N(I) * \sum_{K=1}^{NK} OT*DC(K)*QTY(K)*2*W(K)*RSR*RW(K)*[1-RSS(K)]* [1-DSC(K)] / [R(K)*FR(I)]$$

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
DC(K)	Duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
W(K)	Weight of Kth item (#)
RSR	Shipping cost ($/#)
RW(K)	Item packing weight ratio (shipping Wt/unpacked Wt)
RSS(K)	Repair level ratio (ratio)
DSC(K)	Discard rate of Kth item (ratio)
R(K)	Mean time between failures of Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)

CBS 322100
Preventive Maintenance Labor costs are

$$\sum_{I=1}^{Y} N(I) * \sum_{N=1}^{NM} OT * LPM(N) * RSL / NPM(N)$$

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
LPM(N)	Maintenance time of Nth type PM action (hrs/equip/action)
RSL	O/I maintenance personnel pay rate ($/hr)
NPM(N)	Time between inspections of Nth type PM (hrs/action)
N	Designator for a specific preventive maintenance type
NM	Number of preventive maintenance types

CBS 322200
Preventive Maintenance Material costs are

$$\sum_{I=1}^{Y} N(I) * \sum_{N=1}^{NM} OT * MPM(N) / NPM(N)$$

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
MPM(N)	Material cost of Nth type PM action ($/equip/action)
NPM(N)	Time between inspections of Nth type PM (hrs/action)
N	Designator of a specific preventive maintenance type
NM	Number of preventive maintenance types

CBS 323100
Prime equipment Overhaul Maintenance Labor costs are

$$\sum_{I=1}^{Y} NOH(I) * OHL * RSD$$

Where

NOH(I)	Prime equipment overhaul schedule (equip/yr)
OHL	Overhaul maintenance time (hrs/equip)
RSD	Depot maintenance pay rate ($/hr)

CBS 323200
Prime equipment Overhaul Maintenance Material costs are

$$\sum_{I=1}^{Y} NOH(I) * OHM$$

Where
NOH(I) Prime equipment overhaul Schedule (equip/yr)
OHM Overhaul maintenance material cost ($/equip)

CBS 323300
Transportation of material costs for shipping equipment and other items during Prime equipment overhaul are

$$\sum_{I=1}^{Y} NOH(I) * OHT$$

Where
NOH(I) Prime equipment overhaul schedule (equip/yr)
OHT Material shipping rate ($/equip)

CBS 324000
Support & Test Equipment Maintenance Labor and Material costs are

$$\sum_{I=1}^{Y} N(I) * STES$$

Where
N(I) Prime equipment inventory (equip/yr)
STES Recurring support cost of S&TE ($/prime equip)

CBS 325110
O/I level maintenance shop space costs are

$$\sum_{I=1}^{Y} MSSI(I) * CSI$$

Where
MSSI(I) O/I maintenance shop space (sq. ft./yr)
CSI O/I maintenance space cost ($/sq. ft.)

CBS 325120
Depot level maintenance shop space costs are

$$\sum_{I=1}^{Y} MSSD(I) * CSD$$

Where
MSSD(I) Depot maintenance shop space (sq. ft/yr)
CSD Depot maintenance space cost ($/sq. ft.)

CBS 325210
O/I level maintenance material storage costs are

$$\sum_{I=1}^{Y} ISSI(I) * CSI$$

Where
ISSI(I) O/I maintenance material storage space (sq. ft./yr)
CSI O/I maintenance space cost ($/sq. ft.)

CBS 325220
Depot level maintenance material storage costs are

$$\sum_{I=1}^{Y} ISSD(I) * CSD$$

Where
ISSD(I) Depot maintenance material storage space (sq. ft./yr)
CSD Depot maintenance space cost ($/sq. ft.)

CBS 326000
Technical data maintenance costs for managing the technical data distribution center are

$$\sum_{I=IYI}^{Y} NP * RDM$$

Where

NP	Number of pages in a set of technical data (pages)
RDM	Technical data management costs ($/page)
IYI	Initial year

CBS 327100
Corrective Maintenance Replenishment Spares costs are

$$\sum_{I=1}^{Y} N(I) * \sum_{K=1}^{NK} OT*DC(K)*QTY(K)*CST(K)*DSC(K) / [R(K)*FR(I)]$$

Where

N(I)	Prime equipment inventory (equip/yr)
OT	Prime equipment operating time (hrs/equip/yr)
DC(K)	duty cycle of Kth item (ratio)
QTY(K)	Quantity of Kth item (quantity/item)
CST(K)	Unit cost of the Kth item ($/item)
DSC(K)	Discard rate of Kth item (ratio)
R(K)	Mean time between failures of Kth item (hrs/failure)
FR(I)	Reliability improvement/degradation factor (factor)

CBS 327200
Supply support management costs are

$$\sum_{I=IYI}^{Y} [NSNP + NSNS] * RIM$$

Where

NSNP	Number of new NSNs for prime equipment (NSN)
NSNS	Number of new NSNs for S&TE equipment (NSN)
RIM	Supply support management costs ($/NSN)
IYI	Initial year

CBS 328100
Operator course pay and allowance costs incurred by students during training period are

$$\sum_{I=1}^{Y} LO(I) * RAM * CTO$$

Where

LO(I)	Manning level of operating personnel	(personnel/yr)
RAM	Personnel attrition rate	(ratio)
CTO	Operator training cost	($/student)

CBS 328200
O/I level maintenance personnel pay and allowance costs incurred by students during training period are

$$\sum_{I=1}^{Y} LM(I) * RAM * CTM$$

Where

LM(I)	Manning level of O/I maintenance personnel	(personnel/yr)
RAM	Personnel attrition rate	(ratio)
CTM	O/I maintenance personnel training cost	($/student)

CBS 328300
Depot level maintenance personnel pay and allowance costs incurred by students during training period are

$$\sum_{I=1}^{Y} LP(I) * RAP * CTP$$

Where

LP(I)	Manning level of Depot maintenance personnel	(personnel/yr)
RAP	Personnel attrition rate	(ratio)
CTP	Depot maintenance personnel training cost	($/student)

CBS 330000
Termination cost/value of the Prime equipment is

$$\sum_{I=1}^{Y} NPO(I) * TERM$$

Where

NPO(I)	Prime equipment phase out schedule	(equip/yr)
TERM	Prime equipment net terminal cost/value	($/equip)

APPENDIX I

NAVY VAMOSC TOTAL SUPPORT SYSTEM REPORT FOR
TMS F-4N, FISCAL YEAR 1975

NAVY VAMOSC TOTAL SUPPORT SYSTEM REPORT FOR TMS F-4N, FISCAL YEAR 1975

The five pages of formatted operating and support cost data for the F-4N TMS in Figure I-1 represent the standard reporting formats annually published for each of 103 aircraft TMS in the Navy VAMOSC Total Support System reports.

NALCOMIS-O+S/VAMOSC-AIR

NAVY AND MARINE CORPS AIRCRAFT COST REPORT BY T/M/S

VAMOSC-AIR TSS FY 1975 — ($ IN THOUSANDS; DATA AS LISTED) — T/M/S: F-4N — PAGE 1

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
AIRCRAFT										
NUMBER	36.0	11.0	.0	20.0	.0	.0	.0	.0	.0	67
FLYING HOURS										
REGULAR	12,173.0	6,446.0	.0	12,686.0	.0	.0	.0	.0	.0	31,305
FLEET READINESS SQUADRON	.0	682.0	.0	.0	.0	.0	.0	.0	.0	682
*** TOTAL FLYING HOURS	12,173.0	7,128.0	.0	12,686.0	.0	.0	.0	.0	.0	31,987

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
ORGANIZATIONAL										
MILITARY PERSONNEL COST	6,984.6	2,832.2	.0	.0	.0	.0	.0	.0	.0	9,816
CIVILIAN PERSONNEL COST	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
CONTRACT PERSONNEL COST	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
** SUBTOTAL PERSONNEL	6,984.6	2,832.2	.0	.0	.0	.0	.0	.0	.0	9,816
TEMPORARY ADDITIONAL DUTY	27.6	20.3	.0	46.9	.0	.0	.0	.0	6.2	101
TRAINING EXPENDABLE STORES	16,325.7	.0	.0	.0	.0	.0	.0	.0	.0	16,325
MAINTENANCE SUPPLIES	119.4	82.0	.0	81.7	.0	.0	.0	.0	.0	282
PERSONNEL SUPPORT SUPPLIES	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
POL COSTS	6,425.3	3,021.4	.0	6,262.9	.0	.0	.0	.0	.0	15,709
*** ORGANIZATIONAL SUBTOTAL	29,881.8	5,956.7	.0	6,391.5	.0	.0	.0	.0	6.2	42,236

PAGE 216

Figure I-1. NAVY VAMOSC TOTAL SUPPORT SYSTEM COSTS FOR TMS F-4N, FISCAL YEAR 1975

NALCOMIS-O+S/VAMOSC-AIR

NAVY AND MARINE CORPS AIRCRAFT COST REPORT BY T/M/S

VAMOSC-AIR TSS FY 1975 ($ IN THOUSANDS: DATA AS LISTED) T/M/S: F-4N PAGE 2

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
INTERMEDIATE										
MILITARY PERSONNEL COST	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
CIVILIAN PERSONNEL COST	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
CONTRACT PERSONNEL COST	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
** SUBTOTAL PERSONNEL	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
MAINTENANCE SUPPLIES	2,211.6	519.0	.0	2,947.8	.0	3.7	.0	.0	.0	5,682
*** INTERMEDIATE SUBTOTAL	2,211.6	519.0	.0	2,947.8	.0	3.7	.0	.0	.0	5,682

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
DEPOT SUPPORT										
AIRCRAFT REWORK INTRA-DOD	8,847.5	5,204.1	.0	9,261.9	.0	.0	.0	.0	.0	23,353
AIRCRAFT REWORK COMMERCIAL	408.3	239.1	.0	425.5	.0	.0	.0	.0	.0	1,073
** SUBTOTAL A/C REWORK	9,295.9	5,443.3	.0	9,687.4	.0	.0	.0	.0	.0	24,426
ENGINE REWORK INTRA-DOD	1,366.8	800.3	.0	1,424.4	.0	.0	.0	.0	.0	3,591
ENGINE REWORK COMMERCIAL	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
** SUBTOTAL ENG REWORK	1,366.8	800.3	.0	1,424.4	.0	.0	.0	.0	.0	3,591

PAGE 217

Figure I-1 (continued)

NALCOMIS-O+S/VAMOSC-AIR

NAVY AND MARINE CORPS AIRCRAFT COST REPORT BY T/M/S

VAMOSC-AIR TSS FY 1975 ($ IN THOUSANDS; DATA AS LISTED) T/M/S: F-4N

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
COMPONENT REWORK INTRA-DOD	1,598.8	994.9	.0	1,770.4	.0	.0	.0	.0	.0	4,464
COMPONENT REWORK COMMERCIAL	243.5	142.6	.0	253.8	.0	.0	.0	.0	.0	640
** SUBTOTAL COMP REWORK	1,842.4	1,137.4	.0	2,024.3	.0	.0	.0	.0	.0	5,104
OTHER REWORK MISC DEPOT	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
OTHER REWORK ENG. SUPPORT	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
** SUBTOTAL OTH REWORK	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
*** SUBTOTAL DEPOT SUPPORT	12,505.3	7,381.1	.0	13,136.2	.0	.0	.0	.0	.0	33,122

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUP	MISC	TOTAL
TRAINING SUPPORT										
FRS MILITARY PERSONNEL COST	.0	192.7	.0	.0	.0	.0	.0	.0	.0	192
FRS CIVILIAN PERSONNEL COST	.0	1.5	.0	.0	.0	.0	.0	.0	.0	1
FRS CONTRACT PERSONNEL COST	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
** SUBTOTAL FRS PERSONNEL	.0	194.1	.0	.0	.0	.0	.0	.0	.0	194
FRS TEMP. ADD. DUTY	.0	.7	.0	.0	.0	.0	.0	.0	.0	0
FRS TRAIN. EXPEND. STORES	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
FRS MAINT. SUP.	.0	8.6	.0	.0	.0	.0	.0	.0	.0	8
FRS PERS. SUPP. SUP.	.0	.0	.0	.0	.0	.0	.0	.0	.0	0
FRS POL	.0	474.4	.0	.0	.0	.0	.0	.0	.0	474
** SUBTOTAL FRS	.0	483.7	.0	.0	.0	.0	.0	.0	.0	483

PAGE 218

Figure I-1 (continued)

NALCOMIS-O+S/VAMOSC-AIR

NAVY AND MARINE CORPS AIRCRAFT COST REPORT BY T/M/S

VAMOSC-AIR TSS FY 1975 ($ IN THOUSANDS: DATA AS LISTED) T/M/S: F-4N PAGE 4

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
OPERATIONAL TRAINING	.0	56.0	.0	.0	.0	.0	.0	.0	.0	56
MAINTENANCE TRAINING	210.5	64.3	.0	116.9	.0	.0	.0	.0	.0	391
** SUBTOTAL O/M TRAIN.	210.5	120.3	.0	116.9	.0	.0	.0	.0	.0	447
*** SUBTOTAL TRAIN. SUPP.	210.5	798.2	.0	116.9	.0	.0	.0	.0	.0	1,125

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
RECURRING INVESTMENT										
REPLACEMENT REPAIRABLES	1,022.5	598.7	.0	1,065.6	.0	.0	.0	.0	.0	2,686
MODIFICATIONS	923.6	282.2	.0	513.1	.0	.0	.0	.0	.0	1,719
*** SUBTOTAL RECUR INVEST.	1,946.2	880.9	.0	1,578.7	.0	.0	.0	.0	.0	4,406

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUR	MISC	TOTAL
OTHER FUNCTIONS										
NETS	111.0	33.3	.0	61.6	.0	.0	.0	.0	.0	206
CETS	111.0	33.4	.0	61.6	.0	.0	.0	.0	.0	206
PUBLICATIONS	139.0	42.4	.0	77.2	.0	.0	.0	.0	.0	258
*** SUBTOTAL OTHER FUNCTIONS	361.0	110.3	.0	200.4	.0	.0	.0	.0	.0	672

PAGE 219

Figure I-1 (continued)

NALCOMIS-O+S/VAMOSC-AIR

NAVY AND MARINE CORPS AIRCRAFT COST REPORT BY T/M/S

VAMOSC-AIR TSS FY 1975 ($ IN THOUSANDS; DATA AS LISTED) T/M/S: F-4N PAGE 5

	PACFLT	LANTFLT	NET	MARINE	RESERVE	NAVAIR	OPNAV	NAVEUP	MISC	TOTAL
SUMMARY OF T/M/S										
ORGANIZATIONAL	29,881.8	5,956.7	.0	6,391.5	.0	.0	.0	.0	6.2	42,236
INTERMEDIATE	2,211.6	519.0	.0	2,947.8	.0	3.7	.0	.0	.0	5,682
DEPOT SUPPORT	12,505.3	7,341.1	.0	13,136.2	.0	.0	.0	.0	.0	33,122
TRAINING SUPPORT	210.5	798.2	.0	116.9	.0	.0	.0	.0	.0	1,125
RECURRING INVESTMENT	1,945.2	880.9	.0	1,578.7	.0	.0	.0	.0	.0	4,406
OTHER FUNCTIONS	361.0	110.3	.0	200.6	.0	.0	.0	.0	.0	672
*** OVERALL TOTALS	47,216.7	15,646.4	.0	24,371.9	.0	3.7	.0	.0	6.2	87,245

PAGE 220

Figure I-1 (concluded)

APPENDIX J

NAVY VAMOSC MAINTENANCE SUBSYSTEM DATA FOR TMS F-8H, FISCAL YEAR 1975

NAVY VAMOSC MAINTENANCE SUBSYSTEM DATA FOR TMS F-8H, FISCAL YEAR 1975

This appendix contains the data outputs for one TMS aircraft that are routinely published in the Navy VAMOSC Maintenance Subsystem. Identically formatted outputs are routinely available for the more than one hundred aircraft TMS displayed in Table J-1.

Table J-1. AIRCRAFT TMS FOR WHICH INDIVIDUAL NAVY VAMOSC MAINTENANCE SUBSYSTEM REPORTS ARE ISSUED ANNUALLY

Aircraft TMS	FY 76 Quantity	Aircraft TMS	FY 76 Quantity
A-3B	4	UH-1E	57
EA-3B	10	TH-1L	4
TA-3B	5	AH-1G	17
KA-3B	6	AH-1J	40
A-4C	52	HH-1K	19
A-4E	46	UH-1N	71
TA-4F	33	UH-1H	11
A-4F	46	UH-2C	10
A-4M	48	HH-2D	11
TA-4J	288	SH-2D	8
A-4L	52	SH-2F	42
RA-5C	26	SH-3A	36
A-6A	103	VH-3A	4
EA-6A	16	SH-3D	50
A-6B	52	UH-3A	4
EA-6B	31	HH-3A	4
A-6C	6	SH-3G	56
KA-6D	35	SH-3H	15
A-6E	115	UH/CH-46	218
A-7A	68	CH-53A/D	128
A-7B	51	RH-53D	20
A-7C	35	TH-57A	31
A-7E	210	SP-2H	32
C/LC-117D	38	P-3A	78
C-118B	33	P-3B	100
VC-118B	4	P-3C	92
C-119F	4	RP-3D	1
EC-121K/P	4	WP-3	4
C-130F	5	RP-3A	3
KC-130F	29	TS-2A	75
EC-130G/Q	8	US-2A/B	72
C-131F	24	US-2C	23
C-1A	55	S-2E	30
C-2A	6	US-2D	13
TC-4C	6	S-2G	39
C-9B	8	ES-2D	4
E-1B	15	S-3A	25
E-2A/B	23	T-2B	50
E-2C	10	T-2C	166
QF-86H	3	T-28B	141
F-4B	70	T-28C	113
RF-4B	20	T-29B	7
RF-4J	268	T-33B	20
F-4N	67	QT-33	12
RF-8G	20	T-34B	146
F-8H	25	T-38A	10
F-8J	35	T-39D	27
F-8K	17	CT-39E	6
TF-11A	1	CT-39G	7
F-14A	61	U-3A	3
U-11A	219	AV-8A	46
QV-10A	62	MISCELLANEOUS	99

AIRCRAFT = F-8H

TOTAL COMPONENT MAINTENANCE COSTS(IN THOUSANDS OF $)

ORG.LEVEL LABOR RATE = 15.66 PER HOUR

INT.LEVEL LABOR RATE = 15.66 PER HOUR

ALL NAVY SQUADRONS JULY 74 TO JUNE 75

WORK UNIT CODE	ORGANIZATION MAINTENANCE LABOR SCH	ORGANIZATION MAINTENANCE LABOR UNSCH	ORGANIZATION MAINTENANCE CONSUM SCH	ORGANIZATION MAINTENANCE CONSUM UNSCH	ORGANIZATION SUPPT LABOR	ORGANIZATION TDC LABOR	INTERMEDIATE MAINTENANCE LABOR SCH	INTERMEDIATE MAINTENANCE LABOR UNSCH	INTERMEDIATE MAINTENANCE CONSUM SCH	INTERMEDIATE MAINTENANCE CONSUM UNSCH	INTERMEDIATE SUPPT LABOR	INTERMEDIATE TDC LABOR	INTERMEDIATE ATTR	DEPOT COMPONENT REPAIR NARF D-LAB	DEPOT COMPONENT REPAIR NARF I-LAB	DEPOT COMPONENT REPAIR NARF MAT	DEPOT COMPONENT REPAIR COMMERC LABOR	DEPOT COMPONENT REPAIR COMMERC MAT	DEPOT SURV	DEPOT TDC LABOR	WUC TOTAL COST
03	394	0	0	0	138	0	5	0	0	0	7	0	0	0	0	0	0	0	0	0	543
11	18	83	57	127	24	0	1	1	0	0	4	0	0	17	30	6	0	0	6	0	373
12	2	20	3	16	7	0	0	1	0	0	7	0	0	3	4	3	0	0	1	0	68
13	5	123	3	20	14	4	2	73	0	4	52	0	1	18	39	26	0	0	9	0	393
14	12	91	16	54	13	0	0	6	0	0	4	0	0	4	8	19	0	0	3	0	230
23	12	79	1	13	7	3	2	4	0	0	53	1	2	26	54	38	0	0	17	0	312
29	1	23	0	0	3	0	0	4	0	1	4	0	0	5	6	15	6	1	2	0	71
41	1	15	0	5	4	0	0	2	0	0	1	0	0	5	8	21	0	0	2	0	65
42	4	96	4	12	6	0	1	6	0	1	8	0	0	12	23	123	0	0	70	0	366
44	1	25	1	10	3	0	0	6	0	2	0	0	0	0	0	0	0	0	0	0	47
45	6	57	2	9	13	1	0	3	0	0	5	0	0	4	9	11	0	0	1	0	122
46	3	38	13	48	5	11	0	1	0	0	2	0	0	1	2	4	0	0	1	0	131
47	0	6	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11
49	1	12	0	0	2	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	19
51	4	118	2	16	9	0	0	18	0	2	3	0	0	36	54	26	20	4	7	0	319
56	0	2	0	0	0	0	0	0	0	0	0	0	0	2	3	1	0	0	0	0	9
57	1	139	4	49	7	0	0	21	0	12	3	0	0	32	61	36	0	0	5	0	371
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	28	0	1	6	0	0	26	0	0	0	0	2	0	1	0	2	0	0	0	69
65	0	14	0	1	2	0	0	7	0	0	0	1	0	1	2	0	4	1	0	0	34
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	1	31	1	11	6	1	0	37	0	2	0	0	2	5	7	3	0	0	1	0	108
72	0	12	0	1	2	0	0	10	0	0	0	0	0	0	1	0	0	0	0	0	27
73	0	3	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	7
74	2	81	2	41	35	1	1	54	1	47	0	0	0	23	42	6	0	0	8	0	345
75	2	42	7	38	57	0	0	6	0	0	0	0	5	22	36	8	0	0	36	0	259
76	2	32	0	0	3	0	0	7	0	1	0	0	0	1	1	0	0	0	0	0	47
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	2	7	0	0	2	1	1	2	0	0	0	0	0	1	2	3	0	0	3	0	22
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
97	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3
TOTAL	475	1179	118	472	371	23	14	300	1	71	156	3	12	222	395	350	33	6	176	1	4324

PRE-EX MAT	2
ORG SUPPT LAB	569
ORG TDC MAT	0
INT TDC MAT	0
DEP TDC MAT	0
GRAND TOTAL FOR F-8H	4945

Figure J-1. NAVY VAMOSC MAINTENANCE SUBSYSTEM TOTAL COMPONENT MAINTENANCE COSTS BY WUC FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM
TOTAL COMPONENT MAINTENANCE COSTS ($K)
UNSCHEDULED
ALL NAVY SQUADRONS
JULY 74 TO JUNE 75

* ORGANIZATION LABOR RATE =$15.66 PER HOUR
INTERMEDIATE LABOR RATE =$15.66 PER HOUR

WORK UNIT CODE	MATERIAL LEVEL-1 REPAIR	MATERIAL LEVEL-2 REPAIR	MATERIAL LEVEL-2 ATTRI	MATERIAL LEVEL-3 REPAIR NARF	MATERIAL LEVEL-3 REPAIR COMM.	MATERIAL LEVEL-3 SURVEY	TOTAL MATERIAL	LABOR LEVEL-1 MAINT*	LABOR LEVEL-2 MAINT*	LABOR LEVEL-3 DIRECT NARF	LABOR LEVEL-3 DIRECT COMM.	TOTAL LABOR	TOTAL COST	UNSCHED. COST/ FAILURE ($)	MFHBF	MFHBMA
03	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	.0	.0
11	127	0	0	6	0	6	139	83	1	17	0	101	240	531.	20.9	7.3
12	16	0	0	3	0	1	20	20	1	3	0	23	43	174.	37.8	20.1
13	20	4	1	25	0	9	59	123	73	17	0	213	272	246.	8.5	3.8
14	54	0	0	14	0	3	71	91	6	3	0	100	171	385.	21.3	10.7
23	13	0	0	30	0	10	53	79	4	20	0	104	156	660.	39.9	15.2
29	0	1	0	12	1	2	16	23	4	4	6	37	53	333.	59.0	23.0
41	5	0	0	20	0	2	26	15	2	5	0	22	49	337.	65.6	34.4
42	12	1	0	115	0	65	193	96	6	11	0	113	306	712.	22.0	11.9
44	10	2	0	0	0	0	12	25	6	0	0	30	42	76.	17.1	13.4
45	9	0	0	10	0	1	19	57	3	4	0	64	84	171.	19.4	11.0
46	48	0	0	4	0	1	53	38	1	1	0	41	94	457.	46.1	24.4
47	0	0	0	0	0	0	1	6	0	0	0	7	8	89.	111.2	56.6
49	0	0	0	1	0	0	1	12	0	1	0	14	15	217.	136.9	81.4
51	16	2	0	26	4	7	53	118	18	36	19	192	245	267.	10.3	5.5
56	0	0	0	1	0	0	2	2	0	2	0	4	6	477.	726.8	410.8
57	49	12	0	35	0	5	101	139	21	31	0	192	293	384.	12.4	7.8
61	0	0	0	0	0	0	0	0	0	0	0	0	0	180.	4724.0	1889.6
63	1	0	2	0	0	0	4	28	26	0	2	57	61	135.	20.9	11.7
65	1	0	0	0	1	0	2	14	7	1	4	26	28	226.	75.0	28.0
66	0	0	0	0	0	0	0	0	0	0	0	0	1	69.	1181.0	629.9
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	.0	2362.0
71	11	2	2	3	0	1	19	31	37	5	0	73	92	225.	23.0	11.8
72	1	0	0	0	0	0	1	12	10	0	0	22	24	178.	71.6	29.3
73	0	0	0	0	0	0	0	3	3	0	0	6	6	307.	524.9	185.3
74	41	47	0	6	0	8	102	81	54	23	0	158	260	358.	13.0	8.2
75	38	0	5	8	0	36	87	42	6	21	0	69	155	440.	26.8	12.6
76	0	1	0	0	0	0	1	32	7	1	0	40	41	242.	55.3	28.0
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	.0	2362.0
91	0	0	0	2	0	2	4	7	2	1	0	9	13	399.	295.2	98.4
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	.0	.0
96	0	0	0	0	0	0	0	0	0	0	0	1	1	56.	590.5	377.9
97	0	0	0	0	0	0	0	1	0	0	0	1	1	178.	1181.0	269.9

Figure J-2. NAVY VAMOSC MAINTENANCE SUBSYSTEM COMPONENT UNSCHEDULED MAINTENANCE COSTS BY WUC FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM

COMPONENT COST SUMMARY

UNSCHEDULED

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

	MATERIAL LEVEL-1 REPAIR	MATERIAL LEVEL-2 REPAIR	MATERIAL LEVEL-2 ATTRI	MATERIAL LEVEL-3 REPAIR NARF	MATERIAL LEVEL-3 REPAIR COMM.	MATERIAL LEVEL-3 SURVEY	TOTAL MATERIAL	LABOR LEVEL-1 MAINT	LABOR LEVEL-2 MAINT	LABOR LEVEL-3 DIRECT NARF	LABOR LEVEL-3 DIRECT COMM.	TOTAL LABOR	TOTAL COST	UNSCHED. COST/ FAILURE ($)	MFHBF	MFHBMA
TOTAL ALL WUCS ($K)	472	71	10	321	6	161	1040	1179	300	209	32	1720	2760	315.	1.1	.6
PRCNT PER COST CATEGORY	17.1	2.6	.4	11.6	.2	5.8	37.7	42.7	10.9	7.6	1.2	62.3	100.0			

PERCENT OF COST CATEGORY BY SUBSYSTEM:														TOTAL COST($K) BY SUBSYSTEM	COST($)/FAIL BY SUBSYSTEM
AF	53.5	9.3	10.6	60.9	.0	56.2	52.5	45.4	33.1	30.1	.0	40.6	45.1	1244.	305.
PP	13.0	.9	.0	14.1	19.6	8.1	11.7	11.9	3.3	12.2	19.6	10.6	11.0	303.	504.
AV	33.6	89.9	89.4	24.9	80.4	35.7	35.9	42.7	63.6	57.7	80.4	48.8	44.0	1213.	296.

MAINT. LEVEL COST SUMMARY ($K)

	MATERIAL	LABOR	TOTAL
SQUADRON(1)	472.	1179.	1651.
INTERMEDIATE(2)	81.	300.	381.
DEPOT(3)	488.	241.	728.

FLIGHT HOUR SUMMARY

COMBAT	0.	COMBAT	0.
NON-COMBAT	9448.	NON-COMBAT	6501.
TOTAL FH	9448.	TOTAL FLIGHTS	6501.

				LEVEL-1	LEVEL-2
COST($) PER FH	MATERIAL ONLY	110.	MA/FH	1.7	.6
	MATERIAL+DEPOT LABOR	136.	MH/FH	8.0	2.0
	MATERIAL+ALL LABOR	292.			

COST ($) PER PROGRAM AIRCRAFT 56329.

COST ($) PER OPERATING AIRCRAFT 69004.

Figure J-3. NAVY VAMOSC MAINTENANCE SUBSYSTEM COMPONENT UNSCHEDULED COST SUMMARY INCLUDING MFHBF AND MFHBMA FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSH PAGE 1

TOTAL COMPONENT MAINTENANCE COSTS ($K)

SCHEDULED

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

* ORGANIZATION LABOR RATE =$15.66 PER HOUR
INTERMEDIATE LABOR RATE =$15.66 PER HOUR

WORK UNIT CODE	MATERIAL: LEVEL-1 REPAIR	MATERIAL: LEVEL-2 REPAIR	MATERIAL: LEVEL-2 ATTRI	MATERIAL: LEVEL-3 REPAIR NARF	MATERIAL: LEVEL-3 REPAIR COMM.	MATERIAL: LEVEL-3 SURVEY	TOTAL MATERIAL	LABOR: LEVEL-1 MAINT*	LABOR: LEVEL-1 SUPPORT*	LABOR: LEVEL-1 TDC*	LABOR: LEVEL-2 MAINT*	LABOR: LEVEL-2 SUPPORT*	LABOR: LEVEL-2 TDC*	LABOR: LEVEL-3 DIRECT NARF	LABOR: LEVEL-3 DIRECT COMM.	LABOR: LEVEL-3 INDIRECT	LABOR: LEVEL-3 TDC	TOTAL LABOR	TOTAL COST
03	0	0	0	0	0	0	0	394	139	0	5	7	0	0	0	0	0	543	543
11	57	0	0	0	0	0	57	18	24	0	1	4	0	0	0	30	0	76	133
12	3	0	0	0	0	0	4	2	7	0	0	7	0	0	0	4	0	22	25
13	3	0	0	1	0	0	5	5	14	4	2	52	0	1	0	39	0	117	121
14	16	0	0	5	0	0	21	12	13	0	0	4	0	1	0	8	0	38	59
23	1	0	2	8	0	7	18	12	7	3	2	53	1	6	0	54	0	138	156
29	0	0	0	3	0	0	3	1	3	0	0	4	0	1	0	6	0	15	18
41	0	0	0	1	0	0	2	1	4	0	0	1	0	0	0	8	0	14	16
42	4	0	0	8	0	5	17	4	6	0	1	8	0	1	0	23	0	43	60
44	1	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	4	5
45	2	0	0	1	0	0	4	6	13	1	0	5	0	0	0	9	0	34	38
46	13	0	0	0	0	0	13	3	5	11	0	2	0	0	0	2	0	24	37
47	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	3	3
49	0	0	0	0	0	0	0	1	2	0	0	1	0	0	0	1	0	4	4
51	2	0	0	0	0	0	3	4	9	0	0	3	0	0	1	54	0	71	74
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	3
57	4	0	0	1	0	0	5	1	7	0	0	3	0	1	0	61	0	73	78
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	8	8
65	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	2	0	6	6
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	1	0	0	0	0	0	1	1	6	1	0	0	0	0	0	7	0	15	16
72	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	3	3
73	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
74	2	1	0	0	0	0	4	2	35	1	1	0	0	0	0	42	0	81	85
75	7	0	0	0	0	0	7	2	57	0	0	0	0	1	0	36	0	96	104
76	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	1	0	6	6
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	1	0	1	2	2	2	1	1	0	0	0	0	2	0	7	9
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	2

Figure J-4. NAVY VAMOSC MAINTENANCE SUBSYSTEM COMPONENT SCHEDULED MAINTENANCE COSTS BY WUC FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM

COMPONENT COST SUMMARY

SCHEDULED

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

	MATERIAL							LABOR											
	LEVEL-1	LEVEL-2		LEVEL-3			TOTAL	LEVEL-1			LEVEL-2			LEVEL-3				TOTAL	TOTAL
	REPAIR	REPAIR	ATTRI	REPAIR NARF	REPAIR COMM.	SURVEY	MATERIAL	MAINT	SUPPORT	TDC	MAINT	SUPPORT	TDC	DIRECT NARF	DIRECT COMM.	INDIRECT	TDC	LABOR	COST
TOTAL ALL WUCS ($K)	118	1	2	29	0	15	164	475	371	23	14	156	3	13	1	395	1	1450	1614
ADDITIONAL SCHED. COSTS FOR AIRCRAFT ($K)																			
PREXPENDIBLE CONSUMABLE COST(LEVEL 1)							2												
PREXPENDIBLE CONSUMABLE COST(LEVEL 2)							0												
TDC MATERIAL COST							0												
UNALLOCATED SUPPORT LABOR																		569	
ADJUSTED TOTAL							166											2019	2185
PRCNT PER COST CATEGORY	5.4	.1	.1	1.3	.0	.7	7.5 7.6	21.7	17.0	1.1	.6	7.1	.1	.6	.0	18.1	.1	66.4 92.4	100.0
PERCENT OF COST CATEGORY BY SUBSYSTEM																			
AF	73.9	14.8	.0	57.0	.0	45.1	67.1	93.9	61.5	30.5	65.7	57.7	2.9	26.3	.0	31.7	59.3	62.7	63.1
PP	12.1	3.9	100.0	38.5	8.1	50.1	21.0	3.3	3.9	63.2	18.1	37.3	52.2	56.7	8.1	15.9	17.4	12.2	13.1
AV	13.9	81.3	.0	4.5	91.9	4.9	11.9	2.8	34.6	6.3	16.2	5.0	44.9	17.0	91.9	52.4	23.4	25.1	23.8

MAINT. LEVEL COST SUMMARY ($K)

	MATERIAL	LABOR	TOTAL
SQUADRON(1)	119.	1438.	1557.
INTERMEDIATE(2)	3.	172.	175.
DEPOT(3)	44.	409.	453.

FLIGHT HOUR SUMMARY

COMBAT	0.	COMBAT	0.
NON-COMBAT	9448.	NON-COMBAT	6501.
TOTAL FH	9443.	TOTAL FLIGHTS	6501.

				LEVEL-1	LEVEL-2
COST ($) PER FH	MATERIAL ONLY	18.	MA/FH	.5	.0
	MATERIAL+DEPOT LABOR	61.	MH/FH	5.9	1.2
	MATERIAL+ALL LABOR	231.			

COST ($) PER PROGRAM AIRCRAFT 44590.

COST ($) PER OPERATING AIRCRAFT 54623.

Figure J-5. NAVY VAMOSC MAINTENANCE SUBSYSTEM COMPONENT SCHEDULED MAINTENANCE COST SUMMARY FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM PAGE 1

TOTAL MAINTENANCE ACTION MATRIX

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

UNSCHEDULED MAINTENANCE ONLY

WORK UNIT CODE	LEVEL-1 M-A	R/C	D	T	FAILURES	LEVEL-2 M-A	R/C	A	7	BCM 9	FAILURES	BCM1-8	LEVEL-3 COMM REPAIRS	NARF REPAIRS	NARF SURVEYS	TOTAL M-A	TOTAL FAIL
03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1288	935	14	33	441	13	0	0	1	0	13	13	0	13	0	1292	452
12	451	296	27	12	216	37	16	0	0	0	34	21	0	20	1	469	250
13	2288	754	1307	43	626	1190	975	14	2	3	481	237	0	215	22	2490	1106
14	862	534	62	48	408	47	12	3	1	0	37	33	0	30	3	882	444
23	471	223	92	36	143	210	130	3	0	0	95	77	0	73	4	622	237
29	374	129	97	56	94	115	27	31	1	0	67	59	28	29	2	411	160
41	253	105	72	26	82	68	4	1	0	0	63	61	0	57	4	275	144
42	736	454	113	36	348	134	51	20	0	0	82	61	0	56	5	793	429
44	689	556	92	4	487	84	69	10	6	0	67	3	0	3	0	703	552
45	827	470	121	84	392	117	32	10	0	0	96	75	0	71	4	858	487
46	375	246	27	13	181	27	5	0	0	0	24	22	0	20	2	388	205
47	164	94	12	18	80	6	1	1	0	0	5	4	0	3	1	167	85
49	114	67	13	12	59	11	5	0	0	0	11	6	0	5	1	116	69
51	1613	631	567	158	465	600	123	121	2	0	457	356	43	304	9	1723	917
56	19	3	10	1	3	12	0	2	0	0	10	10	0	10	0	23	13
57	1101	482	434	64	437	472	159	131	0	0	328	200	0	197	3	1213	763
61	4	1	3	0	0	2	2	0	0	0	2	0	0	0	0	5	2
63	741	227	367	32	180	357	281	72	1	1	273	11	5	6	0	809	453
65	311	54	161	28	39	156	68	67	2	0	87	29	17	12	0	337	126
66	9	4	4	1	3	7	0	2	0	0	5	5	0	5	0	15	8
67	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	0
71	733	95	482	58	75	471	384	124	1	1	336	38	0	36	2	798	411
72	266	40	206	2	31	216	101	110	0	0	101	9	0	9	0	323	132
73	43	4	14	2	3	16	15	1	0	0	15	0	0	0	0	51	18
74	1028	343	517	20	299	573	378	132	0	0	428	91	0	84	7	1156	726
75	661	235	381	7	193	354	24	10	0	1	160	318	0	267	51	751	353
76	308	108	107	7	75	111	82	12	0	0	92	10	0	10	0	338	171
77	3	2	0	0	0	1	0	1	0	0	0	0	0	0	0	4	0
91	91	29	14	19	20	12	2	0	0	0	12	10	0	9	1	96	32
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	18	13	1	1	9	8	7	0	0	0	7	1	0	1	0	25	16
97	33	17	11	0	2	7	0	0	0	0	6	7	0	6	1	35	8

Figure J-6. NAVY VAMOSC MAINTENANCE SUBSYSTEM UNSCHEDULED MAINTENANCE ACTIONS AND FAILURES BY WUC FOR TMS F-8H, FISCAL YEAR 1975

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THE FEASIBILITY OF ESTIMATING AVIONICS SUPPORT COSTS EARLY IN T--ETC(U)
SEP 77 J D MORGAN, A B FULLER DAHC15-73-C-0200
UNCLASSIFIED P-1292-VOL-2 IDA/HQ-77-19783 NL

3 OF 3
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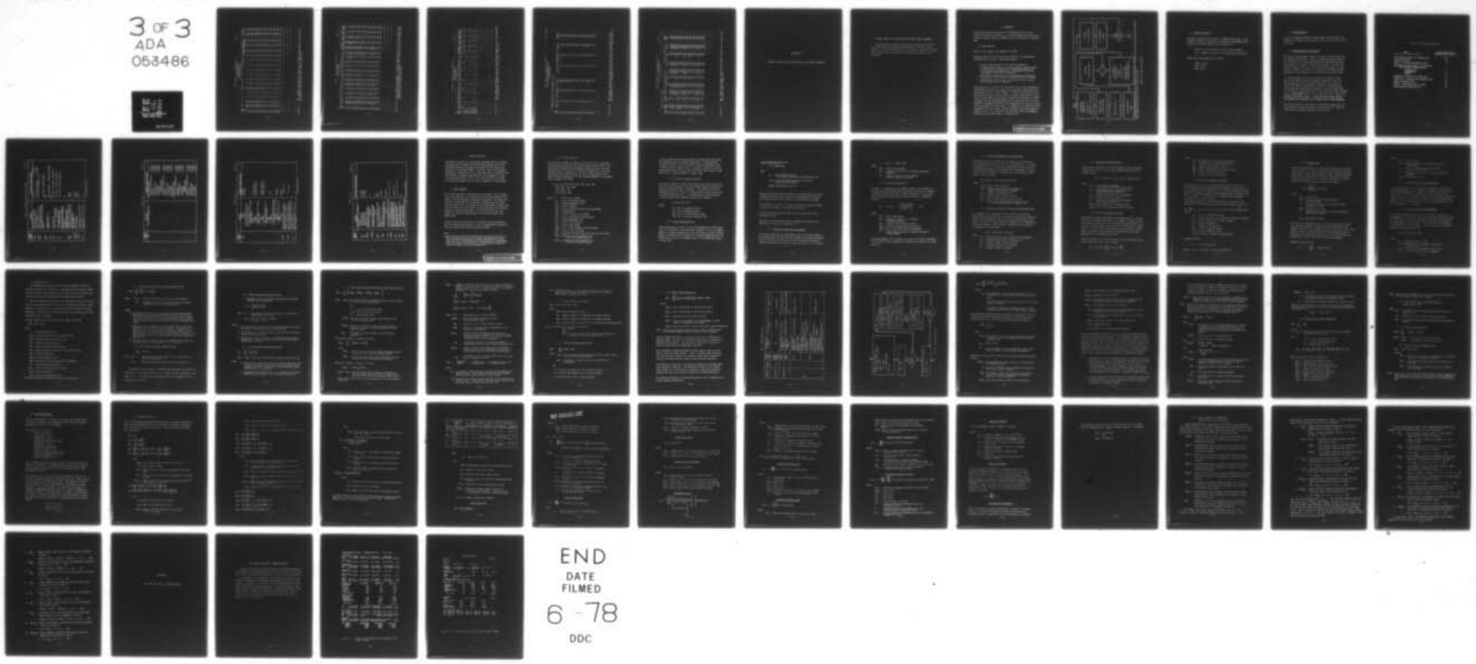

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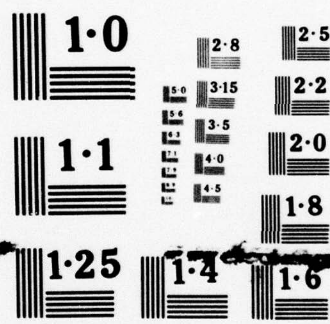

1·0
2·8
2·5
3·15
2·2
3·5
2·0
1·1
4·0
4·5
1·8
1·25
1·4
1·6

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM

TOTAL MAINTENANCE ACTION MATRIX

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

SCHEDULED MAINTENANCE ONLY

WORK UNIT CODE	LEVEL-1 M-A	LEVEL-1 B/C	LEVEL-1 P	LEVEL-1 T	LEVEL-1 FAILURES	LEVEL-2 M-A	LEVEL-2 B/C	LEVEL-2 A	LEVEL-2 Z	LEVEL-2 BCM 9	LEVEL-2 FAILURES	LEVEL-2 BCM1-8	LEVEL-3 COMM REPAIRS	LEVEL-3 NARF REPAIRS	LEVEL-3 NARF SURVEYS	TOTAL M-A	TOTAL FAIL
03	3341	0	0	0	0	8	0	0	0	0	0	0	0	0	0	3348	0
11	502	429	4	0	174	1	1	0	0	0	1	0	0	0	0	503	175
12	72	51	9	0	31	8	6	0	0	0	4	2	0	2	0	76	39
13	121	97	23	0	54	27	24	1	0	0	16	9	0	8	1	133	70
14	217	153	8	0	89	6	0	0	0	0	6	7	0	7	0	219	95
23	27	17	7	0	10	66	28	1	0	1	41	33	0	28	5	91	51
29	19	13	3	0	5	7	2	1	0	0	2	3	0	3	0	25	7
41	22	17	3	0	10	3	0	0	0	0	3	3	0	3	0	22	12
42	123	116	1	0	44	13	6	2	0	0	9	4	0	4	0	135	52
44	42	41	1	0	27	0	0	0	0	0	0	0	0	0	0	42	27
45	120	111	4	0	66	5	0	0	0	0	5	5	0	5	0	122	71
46	68	61	2	1	43	1	0	1	0	0	0	0	0	0	0	68	43
47	18	15	0	0	8	0	0	0	0	0	0	0	0	0	0	18	8
49	15	13	0	0	8	0	0	0	0	0	0	0	0	0	0	15	8
51	84	65	11	1	29	11	4	1	0	0	7	6	1	4	0	90	36
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	44	37	4	0	19	8	0	1	0	0	6	6	0	6	0	48	16
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	13	8	4	0	4	4	3	1	0	0	3	0	0	0	0	14	7
65	13	7	6	0	1	5	2	3	0	0	2	0	0	0	0	14	3
66	3	1	1	0	1	1	0	0	0	0	1	1	0	1	0	4	2
67	3	3	0	0	1	0	0	0	0	0	0	0	0	0	0	3	1
71	18	7	8	0	1	9	6	2	0	0	6	0	0	0	0	22	7
72	2	2	0	0	2	1	0	1	0	0	0	0	0	0	0	3	2
73	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
74	34	19	12	0	5	10	7	2	0	0	7	1	0	1	0	35	12
75	56	41	6	0	14	4	0	0	0	0	4	4	0	4	0	58	18
76	33	27	2	0	5	3	3	1	0	0	2	0	0	0	0	35	7
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	18	8	3	1	5	4	1	0	0	0	4	3	0	2	1	19	9
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
97	6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	6	0

Figure J-7. NAVY VAMOSC MAINTENANCE SUBSYSTEM SCHEDULED MAINTENANCE ACTIONS AND FAILURES BY WUC FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM

MAN HOUR MATRIX

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

WORK UNIT CODE	UNSCHEDULED MAINTENANCE LEVEL-1 TOTAL	LEVEL-1 MH/MA	LEVEL-2 TOTAL	LEVEL-2 MH/MA	LEVEL-3 TOTAL	LEVEL-3 MH/MA	SCHEDULED MAINTENANCE LEVEL-1 TOTAL	LEVEL-1 MH/MA	LEVEL-2 TOTAL	LEVEL-2 MH/MA	LEVEL-3 TOTAL	LEVEL-3 MH/MA	SUPPORT LEVEL-1 TOTAL	SUPPORT LEVEL-2 TOTAL	TDC LEVEL-1 TOTAL	TDC LEVEL-2 TOTAL	TDC LEVEL-3 TOTAL
03	0	.0	0	.0	0	.0	25138	7.5	289	36.1	0	.0	8790	468	0	0	0
11	5301	4.1	45	3.5	2762	237.6	1177	2.3	44	44.0	0	237.6	1508	234	14	0	2
12	1248	2.8	74	2.0	394	14.3	140	1.9	39	3.9	38	14.3	457	453	18	0	1
13	7855	3.4	4644	3.9	3198	13.5	332	2.7	118	4.4	103	13.5	876	3325	252	0	2
14	5785	6.7	375	8.0	560	19.7	742	3.4	18	3.0	140	19.7	825	252	9	0	63
23	5062	10.7	297	1.4	3389	38.2	748	27.7	151	2.3	1055	38.2	434	3355	198	89	14
29	1453	3.9	271	2.4	468	17.6	60	3.2	8	1.1	81	17.6	182	227	2	0	2
41	983	3.9	100	1.5	734	10.3	55	2.5	0	.0	16	10.3	267	87	0	0	0
42	6109	8.3	379	2.8	1907	15.5	234	1.9	36	2.8	139	15.5	392	494	18	0	62
44	1578	2.3	364	4.3	0	.0	54	1.3	0	.0	0	.0	215	11	0	0	0
45	3631	4.4	194	1.7	736	10.1	363	3.0	10	2.0	72	10.1	828	342	67	0	0
46	2449	6.5	77	2.9	203	10.7	201	3.0	2	2.0	0	10.7	305	125	730	1	20
47	409	2.5	6	1.0	48	14.0	25	1.4	0	.0	0	14.0	158	0	0	0	0
49	796	7.0	29	2.6	125	27.6	60	4.0	0	.0	0	27.6	101	33	0	1	0
51	7563	4.7	1168	1.9	4546	14.7	264	3.1	21	1.9	52	14.7	551	203	0	0	4
56	136	7.2	17	1.4	223	22.6	0	.0	0	.0	0	22.6	6	1	0	0	0
57	8893	8.1	1361	2.9	3771	20.2	86	2.0	11	1.4	99	20.2	432	205	0	0	0
61	7	1.8	16	8.0	0	.0	0	.0	0	.0	0	.0	2	0	0	0	0
63	1805	2.4	1675	4.7	59	7.7	28	2.2	17	4.3	0	7.7	387	6	0	0	0
65	887	2.9	445	2.9	141	11.6	26	2.0	10	2.0	0	11.6	157	5	0	57	0
66	12	1.3	5	.7	17	3.5	4	1.3	1	1.0	3	3.5	12	0	0	0	0
67	16	4.0	0	.0	0	.0	10	3.3	0	.0	0	.0	4	0	0	0	5
71	1996	2.7	2367	5.0	559	14.2	35	1.9	24	2.7	0	14.2	386	22	34	10	0
72	776	2.9	624	2.9	49	5.7	4	2.0	2	2.0	0	5.7	138	13	2	0	1
73	175	4.1	178	11.1	0	.0	7	2.3	0	.0	0	.0	80	1	0	0	0
74	5145	5.0	3456	6.0	3361	40.8	140	4.1	46	4.6	53	40.8	2204	24	56	0	36
75	2655	4.0	408	1.2	3057	17.6	128	2.3	0	.0	60	17.6	3652	15	1	11	3
76	2038	6.6	465	4.2	88	8.9	110	3.3	12	4.0	0	8.9	177	2	0	0	1
77	13	4.3	1	1.0	0	.0	0	.0	0	.0	0	.0	6	0	0	0	0
91	422	4.6	116	9.7	120	12.2	134	7.4	40	10.0	38	12.2	99	0	46	4	0
92	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	0	0	0	0
96	26	1.4	22	2.8	3	4.3	2	2.0	0	.0	0	4.3	17	0	0	0	0
97	51	1.5	4	.6	17	2.9	17	2.8	0	.0	0	2.9	34	36	25	0	0

Figure J-8. NAVY VAMOSC MAINTENANCE SUBSYSTEM MANHOURS BY WUC FOR SCHEDULED AND UNSCHEDULED MAINTENANCE, SUPPORT, AND TECHNICAL DIRECTIVE COMPLIANCE FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM

MAN HOUR MATRIX

ALL NAVY SQUADRONS

JULY 74 TO JUNE 75

WORK UNIT CODE	UNSCHEDULED MAINTENANCE LEVEL-1 TOTAL	MH/MA	LEVEL-2 TOTAL	MH/MA	LEVEL-3 TOTAL	MH/MA	SCHEDULED MAINTENANCE LEVEL-1 TOTAL	MH/MA	LEVEL-2 TOTAL	MH/MA	LEVEL-3 TOTAL	MH/MA	SUPPORT LEVEL-1 TOTAL	LEVEL-2 TOTAL	TDC LEVEL-1 TOTAL	LEVEL-2 TOTAL	LEVEL-3 TOTAL
TOTAL	75275		19172		30435		30324		890		1951		23682	9940	1472	173	215
AVERAGE MH/MA		-4.7		3.5		27.9		6.0		4.3		27.9					
PRCNT AF	45.		33.		35.		94.		66.		28.		62.	58.	31.	3.	60.
AVER. AF		4.4		3.7		38.0		6.2		7.8		38.0					
PRCNT PP	12.		3.		13.		3.		19.		58.		4.	37.	63.	52.	17.
AVER. PP		7.3		1.9		23.5		9.9		2.2		23.5					
PRCNT AV	43.		64.		52.		3.		16.		14.		35.	5.	6.	45.	23.
AVER. AV		4.7		3.6		17.4		2.8		2.6		17.4					

Figure J-9. NAVY VAMOSC MAINTENANCE SUBSYSTEM MANHOURS SUMMARY INCLUDING MANHOURS PER MAINTENANCE ACTION FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F008H TYPE EQUIPMENT = AFSM
TOTAL COST OF CONSUMABLES
ORGANIZATION AND INTERMEDIATE LEVEL ONLY
SELECTED SQUADRONS
JULY 74 TO JUNE 75

* ADJUSTMENT FACTOR = RATIO OF LEVEL-1 REMOVALS TO LEVEL-1 REPARABLE ISSUES FOR SELECTED SQUADRONS

WORK UNIT CODE	LEVEL-1 NUM.REP.ISSUES	LEVEL-1 NUM.CONS.ISSUES	LEVEL-1 CONS.COST	LEVEL-2 NUM.REP.ISSUES	LEVEL-2 NUM.CONS.ISSUES	LEVEL-2 CONS.COST	ADJUSTMENT FACTOR *
03	0.	0.	0.	0.	0.	0.	1.0
11	3.	20.	4002.	0.	0.	0.	1.3
12	7.	4.	461.	0.	0.	0.	1.6
13	108.	19.	788.	0.	12.	325.	1.0
14	9.	11.	534.	0.	0.	0.	1.0
23	11.	44.	624.	1.	2.	1.	1.4
29	11.	13.	22.	0.	2.	24.	1.0
41	9.	6.	426.	0.	0.	0.	1.3
42	5.	20.	280.	0.	1.	22.	1.2
44	6.	160.	551.	0.	30.	65.	1.6
45	10.	45.	549.	0.	1.	9.	1.0
46	1.	10.	1467.	0.	0.	0.	1.7
47	1.	1.	55.	0.	0.	0.	2.0
49	0.	0.	0.	0.	0.	0.	1.0
51	50.	15.	627.	3.	10.	55.	1.1
56	3.	2.	2.	0.	0.	0.	1.5
57	42.	8.	1898.	1.	2.	472.	1.0
61	0.	0.	0.	0.	0.	0.	1.0
63	24.	3.	20.	1.	0.	0.	1.0
65	13.	1.	16.	0.	0.	0.	1.0
66	0.	0.	0.	0.	0.	0.	1.0
67	0.	0.	0.	0.	0.	0.	1.0
71	70.	14.	724.	4.	11.	303.	1.0
72	10.	4.	35.	1.	0.	0.	1.6
73	3.	0.	0.	0.	0.	0.	1.0
74	67.	96.	1658.	11.	8.	3949.	1.0
75	11.	2.	150.	0.	0.	0.	1.1
76	16.	25.	109.	0.	40.	77.	1.0
77	0.	0.	0.	0.	0.	0.	1.0
91	2.	3.	724.	0.	0.	0.	1.0
92	0.	0.	0.	0.	0.	0.	1.0
96	1.	0.	0.	0.	0.	0.	1.0
97	9.	9.	758.	0.	0.	0.	1.0

Figure J-10. NAVY VAMOSC MAINTENANCE SUBSYSTEM TOTAL COST OF ORGANIZATION AND INTERMEDIATE LEVEL CONSUMABLES BY WUC FOR TMS F-8H, FISCAL YEAR 1975

AIRCRAFT = F-8H TYPE EQUIPMENT = AFSM

AVERAGE COST MATRIX (PER REPAIR)

JULY 74 TO JUNE 75

* BASED ON SELECTED SQUADRONS

WORK UNIT CODE	MATERIAL: LEVEL-1 REPAIR* (CONS.)	MATERIAL: LEVEL-2 REPAIR* (CONS.)	MATERIAL: LEVEL-2 ATTRI.*	MATERIAL: LEVEL-3 REPAIR NARF	MATERIAL: LEVEL-3 REPAIR COMM.	MATERIAL: LEVEL-3 SURVEYS	LABOR (LEVEL-3 ONLY): DIRECT NARF	LABOR (LEVEL-3 ONLY): DIRECT COMM.	LABOR (LEVEL-3 ONLY): INDIRECT	DEPOT LABOR RATE
03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	135.02	.00	28320.90	584.25	.00	32092.16	1475.98	.00	2551.00	6.21
12	57.89	.00	1048.19	141.32	.00	707.12	90.76	.00	148.18	6.31
13	26.49	4.42	887.50	180.88	.00	1234.62	72.50	.00	157.50	5.34
14	101.25	.00	2385.35	328.53	.00	3072.43	108.01	.00	219.82	5.46
23	61.73	.00	4144.94	343.31	.00	1791.08	228.67	.00	462.76	6.00
29	.00	23.64	34878.63	436.93	40.33	51979.34	148.58	222.63	199.30	8.28
41	50.91	.00	628.01	269.57	.00	652.25	69.24	.00	109.43	6.60
42	27.73	13.09	1284.02	1855.36	.00	1644.52	47.21	.00	176.59	6.23
44	18.50	24.09	.00	.00	.00	.00	.00	.00	.00	.00
45	18.53	.00	248.40	149.41	.00	249.06	58.42	.00	108.93	5.68
46	201.09	.00	632.31	227.27	.00	604.52	66.26	.00	123.63	6.17
47	.00	.00	447.62	96.67	.00	470.44	92.80	.00	158.30	6.64
49	.00	.00	283.67	220.75	.00	268.32	144.07	.00	268.84	5.22
51	26.17	14.46	23139.05	78.11	82.13	38520.44	113.82	451.59	171.26	7.53
56	.00	.00	2092.55	142.95	.00	2260.67	210.08	.00	300.98	9.23
57	102.73	73.16	1235.03	194.43	.00	1029.80	166.40	.00	311.73	7.83
61	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
63	5.25	.00	1549.43	43.45	75.00	370.18	57.32	412.00	92.18	7.45
65	16.25	.00	862.95	33.33	47.00	1254.21	92.97	258.00	143.56	8.03
66	.00	.00	82.00	29.08	.00	82.00	26.94	.00	39.72	7.62
67	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
71	112.61	5.26	1031.46	87.60	.00	775.52	114.47	.00	174.38	7.98
72	15.79	.00	403.12	31.76	.00	289.31	57.98	.00	76.51	10.18
73	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
74	123.33	122.39	2208.15	95.32	.00	1457.79	265.92	.00	473.02	6.62
75	162.38	.00	2133.25	105.93	.00	1737.24	120.10	.00	208.59	6.72
76	2.33	11.92	499.97	16.46	.00	610.47	68.96	.00	84.96	7.73
77	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
91	.00	.00	599.93	165.53	.00	663.45	79.54	.00	146.12	6.62
92	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
96	.00	.00	309.00	78.10	.00	309.00	32.66	.00	46.86	7.67
97	.00	.00	325.00	31.24	.00	325.00	15.62	.00	26.98	5.50

Figure J-11. NAVY VAMOSC MAINTENANCE SUBSYSTEM AVERAGE REPAIR COSTS BY WUC FOR TMS F-8H, FISCAL YEAR 1975

APPENDIX K

EXTRACT FROM THE CRIER ACCOUNTING COST MODEL HANDBOOK

EXTRACT FROM THE CRIER ACCOUNTING COST MODEL HANDBOOK

This appendix contains two sections extracted from the Cost Reduction Is Everyone's Responsibility (CRIER) user's handbook. The extracted section 2 contains a general overview of the CRIER model; section 3 contains the equations and variables.

2. BACKGROUND

This section provides an overview of the CRIER model which is described in more detail in Section 3. It also discusses capacities, limitations and special features of CRIER which are of interest to a potential user.

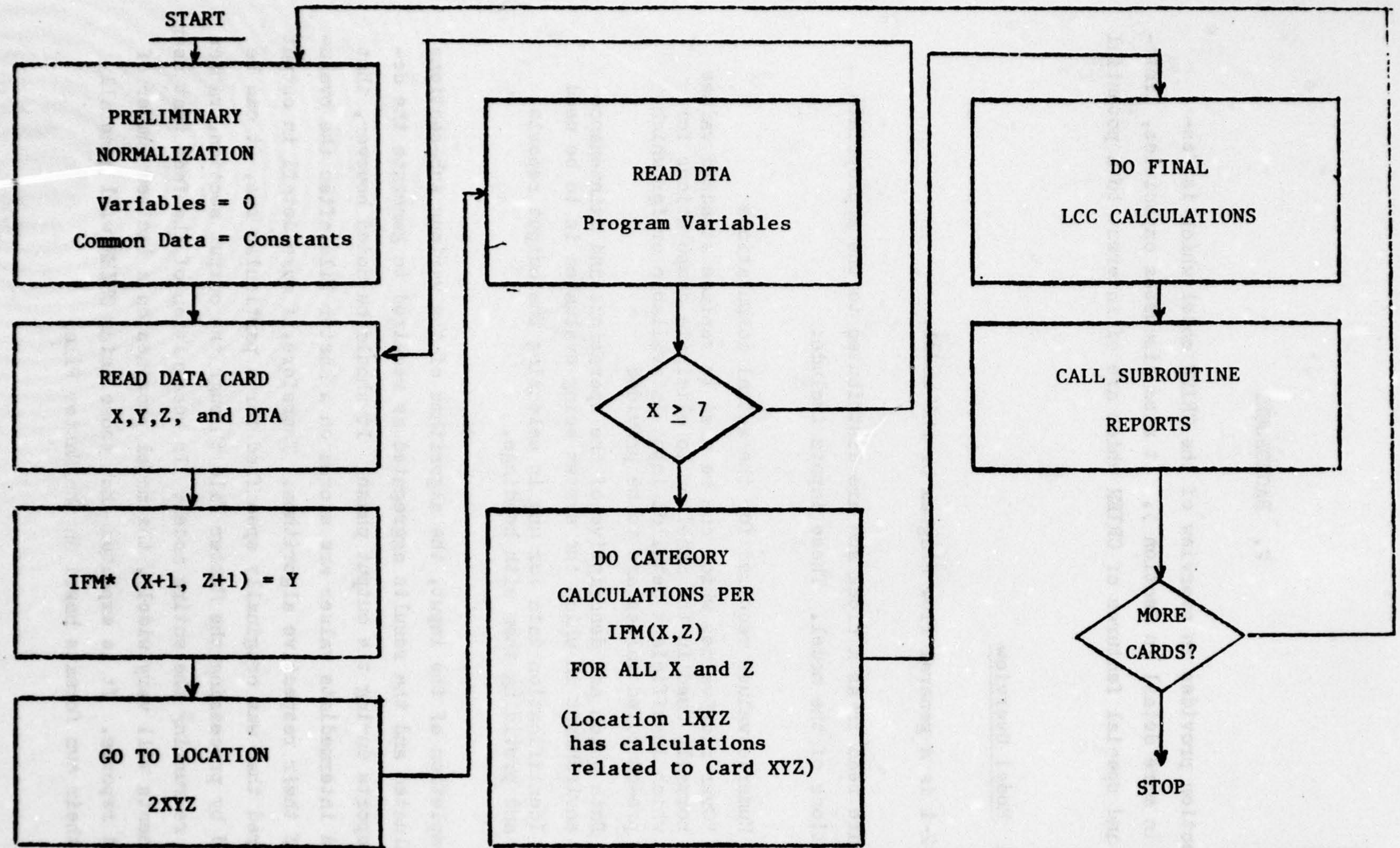
2.1 Model Overview

Figure 2-1 is a general flow diagram of the model.

Inputs are read in as a block and are distributed to the appropriate sub-sections of the model. These inputs include:

1. Numeric values required for the actual computations
2. "Over-ride"values which can be used to replace standard values normally used in the model or to eliminate computations for which insufficient detailed input is available or for which pre-computed values are to be provided
3. Data which are descriptive of the operations and maintenance environment in which the system being evaluated is to be used
4. Identification data for use in selecting the output reports and providing them with headings.

Upon completion of the input, the algorithms of the various sub-sections are evaluated and the results aggregated as required to generate the desired reports during the output phase. It should be noted however, that detailed intermediate values are stored on a Master File after the evaluation of their respective algorithms. Therefore,if more detail in output is desired than was originally specified for a particulan run, it can be obtained by processing the Master File through the output section, rather than by re-running the entire model. In recognition of the fact that user requirements will vary widely, the model provides on a limited number of standard reports. It is expected that those using CRIER will generally design their own formats based on the Master File.



*IFM = Matrix Identifying Proper Flow Through Algorithms

Figure 2-1 Model Flow Diagram

2.2 Model Requirements

The model is presented in the form of a FORTRAN source deck. It was originally compiled on the IBM 370 at Autonetics using FORTRAN-G and requires the following FORTRAN library subroutines:

CDATEV - provides run date for output report headings

DEXP - computes the value of C* in double precision format

Computer size requirements are as follows:

Compile - 264K
Load - 320 K
Run - 256K

2.3 Model Capacities

As with all computer programs, pre-established table sizes limit the capacity of the model in certain areas. Table 2-1 defines those capacity limits.

2.4 Override/Partial Data Features

The model has been designed to permit the user to provide input data at a highly detailed level. However, recognizing that such detail is not available in all cases (and frequently not required), provision has been made for the use of multiple input levels. In effect, the user can assign a value to any valid acronym during input. If that acronym is normally the result of a computation, the algorithm which generates it is by-passed and the input value stored as the result.

In a similar manner, the user can override the "standard" values used in the model for the cost parameters identified in Table 2-2. This feature can be used in special cases where it is known that actual costs would be significantly different from those provided in the model and, perhaps more importantly, to test the sensitivity of the costs of a particular system to wide variationin these "standard" costs. In some cases in Table 2-2, more detail has been provided than the model can accept as input. In such cases the acronym followed by an asterisk (*) represents the "average" value for that parameter.

All standard values are overridden by the applicable common data card (card number 001 through 013) except for those footnoted. These few exceptions are entered on subsequent cards as noted.

Table 2-1 CRIER Size Limitations

Item	Maximum Number Allowed
Prime Hardware Units, i.e. LRU,SRU, etc.	200
New Facility Types	9
Number of Different Maintenance Levels	3
Maintenance Activity Types, e.g. activities with different characteristics	
Organizational	2
Intermediate	2
Depot	1
Categories of Production Startup Costs	10
Categories of Tooling & Test Equipment Costs	50
Support Equipment Types	99
Number of Operational Years in Study	20
Prime Hardware Production Lots	9

Table 2-2 Recommended Standards/Constants Summary

CONSTANT SYMBOL	DEFINITION	RECOMMENDED STANDARDS/CONSTANTS
CPTD	Avg. Cost/Page of Tech Data	CDRL Data $120/page
TDIC	One time cost to introduce a T.O. into inventory	Printing and distribution $4.00/page
LRS(k)	Student Labor Rate at activity k	k=1,2 ($14); k=3,4 ($20); k=5 ($28)
IMCA	Cost to introduce a new part type or new assembly type into government inventory	Part $500/Item, Assembly $1200/Item
IMCA*		$600
RAC	Recurring inventory item management costs	Part $350/Item/Year - Assembly $750/Item/Year
RAC*		$400
DLR	Direct Labor Rate	Org. $5/hr. , Int. $7/hr. , Depot $10/hr.
OLR	Overhead Labor Rate (dollars/ direct dollar)	Org.=$1.00 , Int.=$1.00 , Depot=$1.00
GAR	General Administrative Rate (dollars/direct dollar)	Org.= $0.40, Int.= $0.40, Depot= $0.40
SA	Annual cost for base supply per base stocked item per base inventory location	$50
	<u>Maintenance (Pipeline) time</u>	
ITAT	Intermediate Level turnaround time	10 days
DTAT*	Average depot level turnaround time	66 days
	<u>Order and shippng time</u>	
OAST (1)	Base from depot	15 days
OAST (2)	Base from supplier	90 days
WHPW(k)	Average number of working hours per week at activity (k)	40***
ELH	Average effective labor hours per month per man	128

*** overridden on card 1-1

Table 2-2 (Cont.)

CONSTANT SYMBOL	DEFINITION	RECOMMENDED STANDARDS/CONSTANTS	
DTAT	Depot level turnaround time	CONUS - ORGANIC REPAIR:	
		- Platform or other Major Assy	2.0 months
		- Other LRUs	1.5 months
		- Electronic Modules	1.0 months
		- Gyro Assembly	2.0 months
		- Accelerometer	2.5 months
		- CONTRACTOR REPAIR:	
		- Platform or other Major Assy	2.0 months
		- Other LRUs	1.5 months
		- Electronic Modules	1.0 months
		- Gyro Assembly	2.0 months
		- Accelerometer	2.0 months
		OVERSEAS-ORGANIC REPAIR:	
		- Platform or other Major Assy	3.0 months
		- Other LRUs	2.3 months
		- Electronic Modules	1.5 months
		- Gyro Assembly	3.0 months
		- Accelerometer	3.5 months
		- CONTRACTOR REPAIR:	
		- Platform or other Major Assy	3.0 months
		- Other LRUs	2.3 months
		- Electronic Modules	1.5 months
		- Gyro Assembly	3.0 months
		- Accelerometer	3.0 months

Table 2-2 (Cont.) Sheet 3 of 4

CONSTANT SYMBOL	DEFINITION	RECOMMENDED STANDARDS/CONSTANTS
SCC	CONUS	$8.50/lb.
SCO	Overseas	$16.25/lb.
	Total Average Cost per Trip Pound	
	Detailed Transportation Costs	
	1. Standard Preparation for shipping labor-wage rate:	
	a. CONUS	$1.25/lb. (ship wt.)
	b. OVERSEAS	$1.50/lb. (ship wt.)
	2. Standard Preparation for shipping material rate:	
	a. CONUS	$2.00/lb. (ship wt.)
	b. OVERSEAS	$3.00/lb. (ship wt.)
	3. Ratio of Packaged Item Weight to Unpackaged Item Weight:	
	a. CONUS	2.0
	b. OVERSEAS	2.5
	4. Standard Shipping Rates (one way):	
	a. CONUS base to SRA or vice versa: 1. Via Air	$1.00/lb.
	b. OVERSEAS base to SRA or vice versa: 1. Via Air	$2.00/lb.
SESM(k)	Cost of support equipment spare modules expressed as a portion of the Support Equipment Acquisition at level (k)	.05** for k=1,5
SESO(k)	Lay in cost of O&M ports and material for repair of support equipment expressed as a portion of the support equipment acquisition cost at level (k)	.02** for k=1,5
TCR	Fraction of total TO/manual cost equal to other tech data cost	.25

**overridden by card 508

Table 2-2 (Cont.)

CONSTANT SYMBOL	DEFINITION	RECOMMENDED STANDARDS/CONSTANTS
	Average Manhours per Maintenance action for:	
MRF	Maintenance Records	0.2 hours
SR	Supply Transactions	0.2 hours
TFR	Transportation Forms	0.2 hours
RIFC(T)	Default Value for Reliability Improvement Function in Year 'T' (I=1,20)	1.0
RPFIC(T)	Default Value for Repair Process Improvement Function in Year 'T' (I=1,20)	1.0
CFER	Cost per Field Engineering man month	$5,000
NY	Number of operational years in cost study	10 years
LRI(k)	Average Instructor Labor Rate for training at Maintenance Activity Type k (k=1,5)	k=1,5($30)
PLV(L)	Fraction of MTTR expended on the average for items which RTOK at level L (L=1,2,3)	L=1(0), L=2(1), L=3(.5)
RTITR(L)	Ratio of Recurring Training Cost per course to Initial Training Cost per course at Maintenance level(L) (L=1,3)	1.0 for L= 1,2,3
TR(L)	Annual Manpower Retraining Rate at Maintenance level(L) (L=1,3)	L=1(.25), L-2(.2), L=3(.1)
PPSR	Ratio of Total Piece Part Spares Cost to Program Prime Hardware Cost	0.1
PSD(J)	Probability of Spares Sufficiency Desired at each Spares Inventory Location (J)	.95 for all values of J

3. MODEL DESCRIPTION

The model is divided into three phases; the RDT&E phase, the Acquisition phase, and the Operations and Maintenance phase. Each of the following sub-sections discusses the features and the general sub-equations of a particular phase of the model. When it has appeared appropriate, the descrption of the terms used within the equations are also provided. However, these descriptions are necessarily brief; for precise definitions of each of the terms the user is cautioned to utilize the glossary which is found in Appendix A of this manual.

3.1 RDT&E Submodel

This section discusses the RDT&E phase of the model. **As can be seen,** many of the equations in this phase depend upon "proportionality constants" for which **suggested** values are not provided. **This leaves the** user with two choices. He may attempt to develop values for these constants based on his own personal previous **knowledge** of factors which tend to "drive" that cost element or he may make use of the override feature of the model (see Section on Inputs) and enter **line item** values for either the **sub-equations** or for the total value of the RDT&E costs*.

Whichever choice the user elects, **he is urged to read the equations** and their descriptions **carefully so that, in developing his values, he** does not overlook factors which should be included.

NOTE

*** One of the major tasks of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems over the coming months will be to develop sufficient historical data to permit some kind of estimates of these values. Any assistance that could be provided by users would be much appreciated.**

3.1.1 Primary Equation

The total cost of RDT&E is presumed to include the cost of conceptual studies, design engineering (both hardware and software) costs of the test program (including test hardware and spares as well as the test equipment itself), the costs of training and preparation of technical publications for the RDT&E phase, the cost of design changes introduced during this phase and a cost for program management. The summary equation appears as follows:

R = CS + DE + TSR + TDR + SWR + TNR + ECP + RPM

TSR = TSH + TSS + TSER

TNR = TNER + TNP

RPM = RPMC + RPMG

Where:

R	=	Total Cost Of RDT&E
CS	=	Cost of Conceptual Studies
DE	=	Design Engineering Costs
TSR	=	Cost of Testing
TDR	=	Cost of Tecnical Publications During RDT&E
SWR	=	Software Cost
TNR	=	Cost of Training During RDT&E
ECP	=	Cost of Engineering Change Proposal
RPM	=	Program Management Cost
TSH	=	Cost of Test Hardware
TSS	=	Cost of Test Spares
TSER	=	Cost of Test Equipment for Test Program
TNER	=	Cost of Training Devices
TNP	=	Personnel Cost Associated with Training During RDT&E
RPMC	=	Conractor Program Management Cost per month x number of months
RPMG	=	Government Program Management Cost per month x number of months

As can be seen from the primary equation, the terms TSR, TNR and RPM are themselves sums of subordinate quantities. In employing the "override" feature, the user may elect to enter a pre-computed value of TSR rather than copute the sum. If however, he elects to enter a pre-computed value for TSER, he must also either enter values for TSH and TSS or the inputs necessary to compute them.

3.1.2 The Cost of Conceptual Studies

This phase of RDT&E is assumed to be a paper study involving such elements as: Mission analysis, Cost Effectiveness Analysis, Feasibility Analysis and similar items. Therefore, it will involve the cost of engineering hours and the cost of systems analysis hours plus the cost of computer simulation time. It is assumed that the multiplication of labor rates by labor manhours has been done in advance.

$$CS = EH + SAH + CST$$

Where:

CS = Cost of Conceptual Studies

EH = Cost of Engineering Hours

SAH = Cost of Systems Analysis Hours

CST = Cost of Computer Simulation Time

3.1.3 Design Engineering Costs

Design Engineering is the cost of the actual engineering efforts associated with the design of the new system. Normally, it will be estimated based on the design engineering costs of some previous system of similar design. The equation for the estimation of Design Engineering Costs considers some of the critical elements likely to have significant impact on these costs.

Design Engineering Costs (cont.)

$$DE + (PROP_1)(DEP)$$

Where:

DE = Design Engineering Cost
(To include all Non-Recurring Engineering Costs)

DEP = Known Design Engineering Cost of Previous System of Similar Design

$PROP_1$ = Proportionality Factor 1

These proportionality factors are based on the assumption that DE will increase as allowable failure rates are decreased and as the limits on allowable closure error, alignment time, and MTTRR are lowered.

The arrangement as product or quotient functions has been done merely to point out the direct or inverse proportionality.

(It should also be noted that these "factors" may in fact be of a non-linear nature.)

The user may chose to assign values to these functions and use the equations in the model or simply enter DE.

3.1.4 The Cost of Producing Test Hardware

It has been assumed that the engineering costs for the test hardware were covered under the previous item; therefore, this element represents only the unit cost (in labor and materiel) for producing a piece of hardware multiplied by the number of pieces produced for test purposes.

$$TSH = (DPC)\ (NTH)$$

Where:

TSH = Cost of Test Hardware

DPC = Production Cost Per Unit of Primary Development Hardware

NTH = Number of Units of Primary Hardware Used for Testing During RDT&E

3.1.5 The Cost of Test Spares

Although it is probable that the number of spares to be procured for test purposes will be established according to some empirical standard, the equation relates the number of spares required to the test operating time and the assumed failure rate and thus sets a minimum requirement.

$$TSS = (DPC) \left[\frac{(LTP)\ (TVOP)}{MTBFE} \right] (SF)$$

Where:

TSS = Cost of Test Spares

DPC = Production Cost Per Unit of Primary Development Hardware

LTP = Length of Test Program in Months

TVOP = Test Vehicle Operating Hours Per Month

MTBFE = Mean Time Between Failures (Estimated)

SF = Safety Factor (Assurance of Spares Availability During Testing)

The value assigned to SF is largely the result of the users' confidence in the selected value of MTBFE and the expected distribution of failures over time.

3.1.6 Cost of Test Equipment for Test Program

This equation covers the acquisition of special test equipment for use in preliminary engineering tests and its utilization. It includes the production cost of the special test equipment as wellas the cost of operating and reducing data obtained by that equipment. The utilization factor is assumed to be proportional to the number of flight hours in the test program.

TSER = DPCZ + (NTV) (LTP) (TVOP) (COH)

Where:

TSER = Cost of Test AGE/GSE/TE

DPCZ = Production Cost (During Development) of Special Engineering Test Equipment

NTV = Number of Test Hardware Sets

LTP = Length of Test Program in Months

TVOP = Test Vehicle Operating Hours per Month

COH = Cost per Test Operating Hours (Including Cost of Data Reduction, Personnel, Travel, etc.)

3.1.7 The Cost of Technical Publications During Development

It is assumed that the engineering effort required for technical publications has occurred prior to this point. These costs, therefore, reflect only an average per page cost for writing and editing, multiplied by the number of pages (including drawings) in the documentation. It should be apparent that the number of pages will be some function of complexity of the equipment.

TDR = (CTD) (TDP) + (CD) (TDD)

Where:

TDR = Cost of Technical Publications During Development

CTD = Average Cost per Page of Technical Data

TDP = Number of Pages of Technical Data

CD = Average Cost per Page of Drawings

TDD = Number of Pages of Drawings

3.1.8 The Cost of Training Devices

This equation includes both the primary hardware used for training purposes and the costs of special test equipment used during the training period.

$$TNER = (NIT)\ (DPC) + (NTL)\ (DPCA) + (TVOC)\ (TVOPT)$$

Where:

TNER = Cost of Training Devices (If required by the system being tested)

NIT = Total Number Used for Training Units of Primary Development Hardware

DPC = Production Cost per Unit of Development

NTL = Number of Training Locations

DPCA = Production Cost per Set of Development Test Equipment AGE/GSE/TE

TVOC = Test Vehicle Cost per Operating Hour

TVOPT = Test Vehicle Operating Hours for Training

3.1.9 The Cost of Personnel Training

This equation considers two elements of personnel costs for training, the cost for instructors and the cost for student. Instructor costs are assumed to be continuous over the entire training program, i.e. instructors are paid, housed, fed, etc. over the total period. Student costs, on the other hand, are computed only for those hours actually spent in training on the assumption that students will have other assignments for the balance of the period.

Values established for MCH and MHG should include direct labor costs such as travel,etc. which may be incurred.

$$TNP = (MCH)\ (LTP) \left[GTNH + TMCH)\ (MHG \right]$$

Where:

TNP = Personnel Cost Associated with Training

MCM = Manpower Cost per Month (Instructors)

LTP = Length of Test Program in Months

GTNH = Ground Training Hour with Prime Equipment

TNCH = Test Equipment Training Hours

MHG = Student Cost per Training Hour

3.1.10 The Cost of Engineering Changes

The assumption is made that each engineering change may affect both prime hardware and test equipment and will reflect some fraction of the unit production costs of these items. It is further assumed that alterations to the vehicle housing the prime hardware may be necessary. Note that if changes to the vehicle or Test Equipment are not necessary, VEC and/or PCZ can be set to zero.

The alternate equation may be used provided all the potential costs reflected in the prime equation are considered in setting a value for K.

$$ECP = \left[(PROP_5)(DPC)(QPV)(NV) + (PROP_6)(DPCA) + (VEC)(NV)\right](NECP)$$

Where:

ECP = Cost of Engineering Changes

DPC = Production Cost per Unit of Primary Devlopment Hardware

DPCA = Total Production Cost of Test Equipment

NV = Number of Vehicles

QPV = Number of INS per Vehicle

VEC = Cost to Alter Each Vehicle

$PROP_{5,6}$ = Proportionality Factors

NECP = Number of Engineering Change Proposals

ALTERNATE EQUATION

ECP = (DPC) (NECP) (ECPP)

Where: ECPP = ECP Percent of Total Production Cost

3.1.11 Software Costs

These costs are estimated as some fraction of production costs, that fraction based on the ratio of actual software costs to actual production costs in some previous similar program. The proportionality factor ($PROP_7$) would be set to (1) unless there were valid reasons to assume the new software costs would be significantly higher or lower than those obtained by the simple ratio method.

$$SWR = \left[\frac{DPC}{PCP}\right] (SWRP)\ (PROP_7)$$

Where:

SWR = Software Cost

SWRP = Cost of Software for Previous System of Similar Design

PCP = Production Cost per Unit of Previous Primary Development Hardware

$PROP_7$ = Proportionality Factor

DPC = Production Cost per Unit of Primary Development Hardware (new program)

3.1.12 Total Cost of Testing

This item can be computed as the sum of TSH, TSS, and TSER if sufficient data are available. However, it is more probable that the measure of this will be to compute the ratio of known test costs to the production costs (on previous equipment) and use that ratio as the multiplier on the new production costs. As in the case of SWR, the proportionality factor can be used to adjust the judgement.

ALTERNATE EQUATION FOR TSR

$$TSR = \frac{DPC}{PCP} (TSRP)\ (PROP_8)$$

Where:

TSR = Cost of Testing

TSRP = Cost of Test Program for Previous System of Similar Design

PCP = Cost of Production Hardware for Previous System of Similar Design

DPC = Production Cost per Unit of Primary Development Hardware

$PROP_8$ = Proportionality Factor

3.1.13 Cost of Contractor Program Management

It is assumed during the RDT&E phase that the cost to the contractor of program management will not appear as a separate line item and that all of the items previously discussed will contain some portion of these costs. If it is desirable to estimate what fraction of these total program management costs should be related to a given previous program element, it can be accomplished by considering the percentage of total cost attributable to that element.

3.1.14 Cost of Customer Program Management

This cost has been identified as a ratio in which the internal cost of management of a comparable system is multiplied by the factor defined as the technology index (i.e. the degree to which the state-of-the-art is being pushed by the new system). This cost cannot be estimated by the Contractor. It must be added by the customer if it is considered important in estimating total LCC.

RPMG = (TI) (RPMGP) (PMM)

Where:

TI = Technology Index = $(PROP_9)$

RPMGP = Customer Cost of Management of Comparable System per Month

RPMG = Customer Cost of Management of New System

PMM = Number of Months of Program Management

3.2 Acquisition Costs

The acquisition cost section of the model is intended to define the initial investment costs to the user. Some care must be exercised in applying these equations and assigning values to the various cost elements to be certain that costs are not duplicated in the RDT&E or O&M sections.

The costs computed in this section are intended to be the cost of procuring the system being analyzed, plus the cost of those items (spares, support equipment, documentation, etc.) necessary for the user to make the system operational. The sum of all of these investment costs (A) defines the total acquisition costs, as follows:

A = TTEA + SRAC + CINST + CSU + TSEA + TDA + TNEA + SPHA + TNA

AFEC + FACA + IIMA

Where:

A = Total Acquisition Costs

TTEA = Production Tooling and Test Equipment Costs

SRAC = System Recurring Acquisition Costs

CINST = Equipment Installation Costs

CSU = Production Program Start-Up Costs

TSEA = Support Equipment Acquisition Costs (AGE, GSE, TE)

TDA = Technical Data Costs

TNEA = Training Equipment Costs

SPHA = Spares costs, including O&M Parts and Material

TNA = Initial Training Course Costs

AFEC = Acquisition Field Engineering Costs

FACA = New Facility Costs

IIMA = Initial Item Management Costs

The above cost elements are defined in further detail below:

3.2.1 TTEA = Production Tooling and Test Equipment Costs

$$TTEA = \sum_{i=1}^{n} \left[(CTE_i) \quad (QTE_i) \right]$$

Where: CTE_i = Cost of the i^{th} item of Tooling or Test Equipment

TE_i = Quantity of the i^{th} item of Tooling or Test Equipment required to achieve the production rate.

NOTES:

1) The quantity TTEA includes only the costs of additional equipment necessary to achieve the required production rate. It does not include the equipment identified and costed in the RDT & E submodel. Also, the model assumes that production tooling and test equipment costs are not included as part of system recurring acquisition cost (SRAC).

2) The symbol n in the expression for TTEA above reflects the total number of items of tooling or test equipment. This quantity is not explicitly read into the model computer program. Rather, it is implicitly reflected by the number of cards containing tooling or test equipment information. This notation permits the symbol n to be used to reflect totals of different types of entities in summations defined below.

3) The model computer program allows for a maximum of 50 items of production tooling or test equipment, i.e., $n \leq 50$ above.

3.2.2 SRAC = System Recurring Acquisition Costs

$$= \sum_{i=1}^{n} NS_i \quad UC_i$$

Where: NS_i = Quantity of systems purchased in lot (or fiscal year), i (not including spares)

UC_i = Average unit cost per system in lot (or fiscal year), i

The summation above provides for purchases involving more than one lot or fiscal year. A procurement consisting of a single lot buy is reflected in the model by n = 1. The model computer program provides for a maximum of 9 lots should they be required.

3.2.3 CINST = Equipment Installation Costs

= (average cost per installation) (total number of systems purchased excluding spares)

$$= (CI) \sum_{i=1}^{n} \left[\left(NS_i \right) \left(CI_i \right) \right]$$

Where: CI = The average cost per unit to install a system in the using vehicle or facility

NS_i = Same as in Section II above, $i = 1,2 \ldots, n$

NOTES:

1) The model assumes that the number of systems installed is equal to the number of systems purchased, excluding spares.

2) The quantity, CI, includes any repair costs that may be incurred during installation and test.

3) The quantity, CINST, is usually a user developed cost and may be omitted when a contractor computes the life cycle costs, should this value not be known.

3.2.4 CSU = Production Program Startup Costs

$$CSU = \sum_{i=1}^{n} \left[CSUA_i \right]$$

Where: $CSUA_i$ = The cost of the i^{th} item of program start-up activity.

NOTES:

1) Start-up costs include the costs of activities necessary to get a production program underway such as drawing update, factory training, qual test, initial setup of production flow, demonstrations, etc., as applicable.

2) The model computer program allows for a maximum of 10 items of program start-up activity, i.e., n can equal at most 10.

3.2.5 TSEA = Support Equipment Acquisition Costs (AGE, GSE or TE)

$$TSEA = \sum_{k=1}^{n} \left[(TSEA_k + SEAMOD_k + SEAPAR_k)\ (NRS_k) \right]$$

Where: $TSEA_k$ = The support equipment acquisition cost per repair station at the k^{th} level of maintenance.

and:

k = 1, implies Organizational Level

k = 2, implies Intermediate Level

k = 3, implies Depot Level

$SEAMOD_k$ = The cost of support equipment spare modules at the k^{th} level of maintenance.

$SEAPAR_k$ = The cost of the initial lay-in of piece parts and material for repair of support equipment at the k^{th} level of repair.

NRS_k = The number of repair stations at the k^{th} level of maintenance.

The quantity, $TSEA_k$, is computed as follows:

$$TSEA_k = \sum_{i=1}^{n} \left[(NSE_{ki})\ (CSE_{ki}) \right]$$

Where:

NSE_{ki} = Quantity of the i^{th} item of support equipment required at each k^{th} level maintenance repair station.

CSE_{ki} = Cost of each i^{th} item of support equipment required and each k^{th} level maintenance repair station.

The quantity, NSE_{ki}, is computed as follows:

$$NSE_{ki} = (RSE_{ki}) / (ASE_i)$$

Where: RSE_{ki} = The anticipated usage requirement, expressed in hours per month, for the i^{th} type of support equipment at the k^{th} level of maintenance, repair station.

Usage time includes repair time and calibration time and is computed as follows:

RSE_{ki} = (Number of hours per month that type $_i$ of support equipment is needed for repair at each k^{th} level repair station) + (Number of hours per month that type $_i$ of support equipment is needed for calibration at each k^{th} level repair station).

$$= \sum_{j=1}^{n} \left\{ \left[(OPH) \Big/ (MTBMA_j) \right] \left[(QPS_j)\ (NOPS_k)\ (SETT_{kij}) \right] + \left[(QPS_j)\ (NOPS_k)\ (OPH\ \ CF_j)\ (SECT_{kij}) \right] \right\}$$

Where: OPH = Operating hours per system per month.

$MTBMA_j$ = Mean Time between maintenance actions for the j^{th} LRU or SRU.

QPS_j = Quantity of the j^{th} LRU or SRU per system.

$NOPS_k$ = Quantity of operating systems maintained at the k^{th} level of maintenance.

$SETT_{kij}$ = Average hours per maintenance action that the i^{th} item of support equipment will expend from fault isolation through acceptance testing of the j^{th} LRU, or SRU at the k^{th} level of maintenance.

CF_j = Calibration frequency, or the average number of calibrations of the j^{th} LRU or SRU, per operating hour.

$SECT_{kij}$ = Average hours per calibration of the ith item of support equipment will be employed in calibration of the j^{th} LRU or SRU at the k^{th} level of maintenance.

ASE_i = The number available hours per item of the i^{th} type of support equipment per month.

$$ASE_i = \frac{720\ \text{hours}}{\text{month}} \times \frac{WD}{7\ \text{calendar days}} \times \frac{WS}{3\ \text{available shifts}} \times UF_i$$

Where:

WD = The number of working days per week that will be available for repair activity. Under normal conditions it may be assumed that the repair shop will operate 5 days per week.

WS = The number of working shifts per day that will be available for repair activity. Under normal conditions it may be assumed that the repair shop will operate one shift per day.

UF = Utilization Factor, or the estimated fraction of the month that the i^{th} type of support equipment will be available for use. Under normal conditions, UF ~0.7.

3.2.6 TDA = Technical Data Costs

TDA = (CPTD + TDIC)(TDV + TDG)

Where:

CPTD = Cost per page (See Figure 3)

TDV = Number of pages of TO's/Manuals for primary hardware

TDG = Number of pages of TO's/Manuals for support equipment.

TDIC = One-time cost to introduce a T.O. into inventory (See Appendix B)

NTOD = (TCR) (TDA)= cost of non-TO type technical data required

and

TCR = The cost of non-TO type technical data expressed as a fraction of the total cost of TO's.

3.2.7 TNEA = Training Equipment Costs

$$TNEA \sum_{n=1}^{3} (TNEA_k)\ (NRS_k)$$

Where: $TNEA_k$ = The training equipment acquisition cost per repair station at the k^{th} level of maintenance.

NRS_k = The number of repair stations at the k^{th} level of maintenance.

and:

k = 1, implies Organizational Level training equipment

k = 2, implies Intermediate Level training equipment

k = 3, implies Depot Level training equipment

3.2.8 SPHA = Initial Spares Cost

$$SPHA = \left(\sum_{K=3}^{K=5} \left(SLRU_K + SSRU_K \right) \left(NRS_K \right) \right) + SCOND + SPARTS$$

Where:

$SLRU_K$ = Cost of spare LRUs* at each activity Type K

$SSRU_K$ = Cost of spare SRUs* at each activity Type K

NRS_K = Quantity of activity Type K in study

SCOND = Cost of spare assemblies for replenishment of items coded for condemnation upon failure

SPARTS = Cost of the initial lay-in of spare piece parts and material

*Note - The terms LRU and SRU are generalities. Table 3-1 defines specifically which hardware items are included in each inventory.

The basic CRIER algorithms use two distinct steps in the computation of $SLRU_K$ and $SSRU_K$. The first is to determine which items are candidates for sparing at each inventory. The second is to calculate the quantity of each to be spared and the corresponding total cost.

Each Intermediate or Depot maintenance activity type can have up to two spares inventories (SLRU and SSRU). Table 3-1 defines these inventories, the units which are candidate for stocking at each, and the equation to calculate the demand rate and inventory level period for each unit.

The quantities of each unit to be spared are computed by a Poisson spares cost optimization algorithm. This algorithm is shown in block diagram form in Figure 3-1. This process is repeated for each spares inventory assuring that each has the required probability of spares sufficiency.

The individual probability of sufficient spares for unit i is given by the Poisson cumulative probability

Table 3-1. Spares Prediction Data

Maintenance Level	Activity Type	Inventory Cost Variable Name	Items Candidate for Stocking in this Inventory	Item Demand Rate Computation $OSPI_{i,1}$	Inventory Stock Level Period $OSPI_{i,3}$
Organization	1 or 2	SLRU(1) SLRU(2) SSRU(1) SSRU(2)	None	Not applicable	Not applicable
Intermediate	3 or 4	SLRU(3) SLRU(4)	All items removed at Organizational Level $REMK_i=1$	$(QPS_i)(PUFR_i)(K3_i)$	$(ITAT_i + (COND_{2,i}+NRTS_i)(OAST_i)$
		SSRU(3) SSRU(4)	All items removed at Intermediate Level $REMK_i=2$	$(QPS_i)(PUFR_i)(1-NRTS_i)$	$(NRTS_i+COND_{2,i})(OAST_i)+(1-NRTS_i)$ (ITAT)
Depot	5	SLRU(5)	All items removed at Organizational Level ($REMK_i=1$) and are sometimes returned to the depot for repair ($NRTS_i>0$)	$(QPS_i)(PUFR_i)(K3_i)(NRTS_i)$	$DTAT+(COND_{3,i})(OAST_2)$
		SSRU(5)	All items removed at Intermediate ($REMK_i=2$) and sometimes returned to the depot for repair ($NRTS_i>0$)	$(QPS_i)(PUFR_i)(K3_i)$ $(1-NRTS_{NABC_i})(1-NRTS_i)$	$DTAT+(COND_{3,i})(OAST_2)$
			All items removed at Intermediate ($REMK_i=2$) and its next higher Assembly ($NABC_i$) is sometimes returned to the depot for repair	$(QPS_i)(PUFR_i)(K3_i)$ $(NRTS_{NABC_i})$	
			All items removed at Depot	$(QPS_i)(PUFR_i)(K3_i)$	

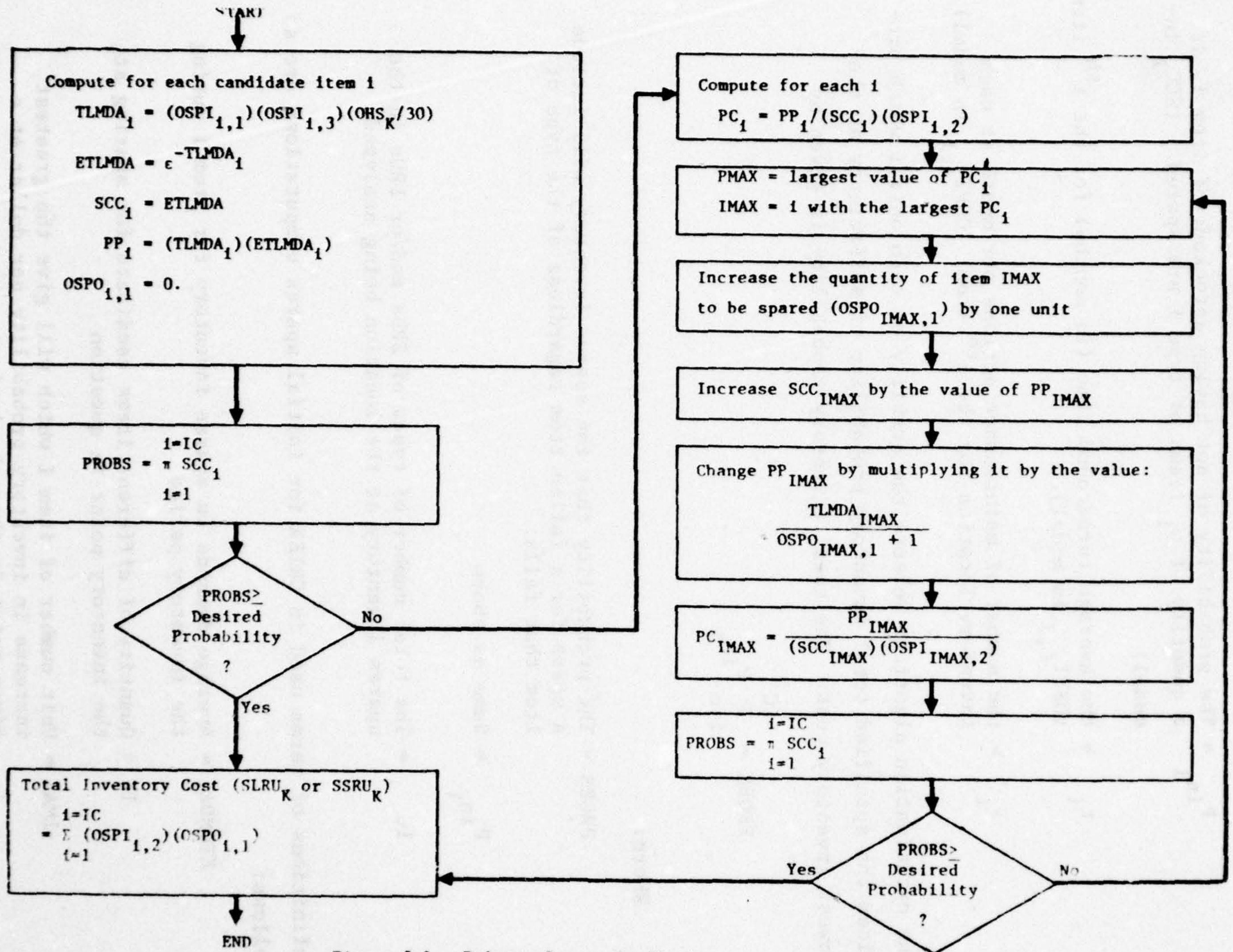


Figure 3-1. Poisson Spares Prediction

$$P_{in_i} = \sum_{x=o}^{x=n_i} \frac{e^{-\lambda_i t_i} (\lambda_i t_i)^X}{X!}$$

Where:

P_{in_i} = The probability of not having astockout of item i, if a quantity of n_i items of type i are spared. (SCC_i in model)

t_i = the average turnaround time (in months) for the i^{th} item. ($OSPI_{i,3}$ in model).

λ_i = the number of maintenance actions per month at each inventory location for the i^{th} item. ($OSPI_{i,1}$ in model)

The optimization algorithm selects the quantity of each unit i which provides the specified total inventory probability of sufficiency at the lowest inventory cost. The total inventory probability is given by

$$PROBS = \prod_{i=o}^{IC} P_{in_i}$$

Where:

PROBS = The probability that the spares inventory will include a spare for a failed item regardless of the type of item that fails.

P_{in_i} = Same as above

IC = The total number of types of SRUs and/or LRUs in the spares inventory at the location being analyzed.

Definitions of terms used in CRIER for initial spares computations are as follows:

$ETLMDA_i$ = Average demands on spares inventory for item i during the inventory period

IC = Quantity of different items candidate for sparing at the inventory point in question

IMAX = Unit number of item i which will give the greatest increase in inventory probability per dollar at a given point in the calculations

OHS_K = Total operating hours supported by the inventory

$OSPI_{i,1}$ = Total demand rate per operating hour for item i

$OSPI_{i,2}$ = Average unit price of item i

$OSPI_{i,3}$ = Stock level period for unit i (i.e., average time from unit failure until it is replaced or repaired)

$OSPO_{i,1}$ = Total quantity of item i to be spared

PC_i = Comparative increase in inventory probability per dollar if one more item i were to be spared

PP_i = The increase in unit probability for item i if one more is to be spared

PROBS = Total system probability of spares sufficiency

SCC_i = Computational value

TC = Total cost of resultant spares inventory

The above computation determines the cost of spare LRUs and SRUs required to provide each inventory location with a pre-determined probability of not having a stockout of any item (PROBS). This computation includes all LRUs and/or SRUs without regard to whether they are to be repaired or thrown away (discarded) upon failure. However, should a LRU or SRU be determined by design to be condemned (discarded) upon failure, it is necessary to compute the total cost of that item, for LCC purposes, as part of the acquisition costs. This calculation is performed based on the following rationale:

1. The quantity of the i^{th} condemned item (n_i) is computed as a final result equation 4, above. This quantity is multiplied by the number of inventory locations that stock the item, and the result is designated $NNCOND_i$. The quantity $NNCOND_i$ is then the total number of each item i, intended by design to be discarded upon failure, that are included in the inventory to satisfy the probability P_{in_i}.

2. The total quantity of the i^{th} item that is intended by design to be discarded upon failure is then computed for the life cycle period. This quantity is designated $TCOND_i$.

3. The difference between $TCOND_i$ and $NNCOND_i$ (defined below as $NCOND_i$) is then the quantity of additional items not included in the total inventory to satisfy P_{in} that must be purchased to satisfy total program requirements for the life cycle period.

SCOND = Cost of LRU's and SRU's that are discarded (condemned) upon failure by design (cost of replenishment spares for replacing condemned reparable items is treated in the (&M submodel).

NOTE: The LRU's and SRU's costed herein are those items identified by an ORLA, LOR or Maintenance Philosophy at the beginning of the program as the items that will be condemned or discarded upon failure. Normal attrition of reparable items is not included here but is included in the quantity RS of the O&M submodel, Page 3-34.

$$SCOND = \sum_{i=1}^{n} (NCOND_i) \quad (CCOND_i)$$

Where:

$NCOND_i$ = The quantity of the i^{th} discardable item, in addition to those computed, costed and accounted for in the computation for SLRU or SSRU, that are required to satisfy the program requirements for the life of the program.

$CCOND_i$ = The cost of the i^{th} discardable item.

n = The total number of discardable items.

and:

$NCOND_i = TCOND_i - NNCOND_i$

If $NNCOND_i$, $TCOND_i$ then $NCOND_i = 0$

and:

$$TCOND_i = \frac{(OPH)\ (NS)\ PIUP)}{MTBMA_i}$$

Where:

$TCOND_i$ = The total quantity of the i^{th} discardable item required to satisfy the program for the life cycle period. $TCOND_i$ is rounded up to next integer.

OPH = The average number of operating hours per month per system.

NS = The total quantity of operating systems.

PIUP = Life Cycle period or program inventory usage period in months.

$MTBMA_i$ = Mean time between maintenance actions for the i^{th} discardable item.

$NNCOND_i = (N_i)\ (IL)$

n_i = The quantity of the i^{th} discardable item that was added to the spares inventory by equation 4 above.

IL = The number of inventory locations that stock the item i.

The cost of the initial lay-in of spare piece parts is estimated as a fraction (denoted as PPSR) of the cost of System Recurring Acquisition Costs (SRAC), i.e.,

$$SPARTS = (PPSR)\ (SRAC)$$

3.2.9 TNA = Initial Training Course Costs

$$TNA = \sum_{k=1}^{5} TNAK_K$$

Where:

$TNAK_K$ = Training costs for the initial training of personnel maintenance activity type.

and:

k = 1, 2 implies Organizational Level

k = 3, 4 implies Intermediate Level

k = 5, implies Depot Level

$$TNAK_K = \left(ICL_K\right)\left(NC_K\right)\left[\left(LRI_K\right)\left(NIC_K\right) + \left(LRS_K\right)\left(NSC_K\right)\right] + CP_K + CM_K$$

Where, for the k^{th} level of maintenance:

ICL_k = Initial course length in hours

LRI_k = Instructor labor rate ($ per hour)

NIC_K = Total number of instructors per course

NSC_K = Number of students per course

LRS_k = Student labor rate for ($ per hour)

NC_k = Number of courses to be given

CP_k = Total course preparation cost

CM_k = Total course material cost

NOTE: Training costs computed herein are the initial training costs only, i.e., recurring training is not included.

3.2.10 AFEC = Acquisition Field Engineering Costs

= (NFE) (CFER) (NRS)

Where:

NFE = The number of field engineering man-months required per repair station

CFER = The cost per field engineer in dollars per month.

NRS = The number of repair stations requiring field engineering support.

3.2.11 FACA = New Facilities Cost

$$FACA = \sum_{j=1}^{n} (CFACA_j) \quad (QFACA_j)$$

Where: $CFACA_j$ = The cost of the j^{th} new facility

$CFACA_j$ = The quantity of the j^{th} new facility.

3.2.12 IIMA = Initial Item Management Costs

IIMA = IMCA (NPTA + NATA)

Where:

IMCA = The cost to introduce a new part type or new assembly type into the government inventory.

NPTA = The number of new part types to be introduced into inventory.

NATA = The number of new assembly types to be introduced into inventory.

NOTE: This item is the cost of introducing a new part type or assembly type into the government inventory. The recurring costs for maintenance of the inventory management system is included in the O&M submodel, page

3.3 O&M Model Equations

The O&M cost computed by the model is the total cost of maintaining all items of equipment at all maintenance levels over the estimated operational life cycle of the equipment.

The total cost is the sum of:

- Direct Labor Costs
- Direct Material Costs
- Overhead Labor Costs
- General and Administrative Costs
- Transportation Costs
- Replenishment Spares Cost
- Replacement Training Costs
- Support Equipment Maintenance Costs
- Maintenance Management Data Costs
- Inventory Management Costs

Each of these is computed and summed across all items and then across location if applicable. The final summation is over time. Provisions are also made for deleting O&M costs for those years in which items are covered by warranty.

In the equations of the O&M submodel, the subscripts "k" and "l" are both used to identify classes of maintenance activities. There is, however, an important difference between them. The subscript "l" refers to a maintenance level, i.e. organizational, intermediate, or depot, numbered 1, 2, and 3 respectively. The model provides, however, for two types of organizational facilities and two types of intermediate facilities. "Types" of facilities would for example, be differentiated on the basis of aircraft type supported, flight schedules, etc. These are identified by the "k" subscripts in accordance with the following scheme:

For $k = 1,2;\ l = 1$

For $k = 3,4;\ l = 2$

For $k = 5;\ \ l = 3$

3.3.1 Deployment Factors

Prior to calculating the operating and maintenance costs numerous operational factors such as operating hours at each location, the number of locations, etc., are computed from the input data set. The following equations define these computations

$$NRS_5 = ND$$

$$NRS_4 = \left(NIPD_2\right)\left(ND\right)$$

$$NRS_3 = \left(NIPD_1\right)\left(ND\right)$$

$$NRS_2 = \left(\left(NOPI_{2,1}\right)\left(NIPD_1\right) + \left(NOPI_{2,2}\right)\left(NIPD_2\right)\right)\left(ND\right)$$

$$NRS_1 = \left(\left(NOPI_{1,1}\right)\left(NIPD_1\right) + \left(NOPI_{1,2}\right)\left(NIPD_2\right)\right)\left(ND\right)$$

where:

NRS_K = Total number of type K activities (K=1 thru 5)

ND = Total number of Depots

$NIPD_1$ = Number of the 1st type (=3) Intermediate activity per depot

$NIPD_2$ = Number of the second type (K=4) Intermediate activities per depot

$NOPI_{N,M}$ = Number of the n^{th} type Organizational activity per m^{th} type Intermediate activity

$$NV_N = \left[\left(NVPO_1\right)\left(NRS_1\right) + \left(NVPO_2\right)\left(NRS_2\right)\right]\left[OPH_N\right]$$

$$NI_N = \left[\left(QPV_1\right)\left(NVPO_1\right)\left(NRS_1\right) + \left(QPV_2\right)\left(NVPO_2\right)\left(NRS_2\right)\right]\left[OPH_N\right]$$

where:

NV_N = Number of vehicles active in year N

NI_N = Number of systems active in year N

$NVPO_K$ = Number of vehicles (nominal value) per type K activity (K=1 or 2)

NRS_K = Total number of K type activities

OPH_N = Portion of total systems active in year N

QPV_K = Number of systems per vehicle at type K activity (K=1 or 2)

$$OHS_1 = \left(SOH_1\right)\left(QPV_1\right)\left(NVPO_1\right)$$

$$OHS_2 = \left(SOH_2\right)\left(QPV_2\right)\left(NVPO_2\right)$$

$$OHS_3 = \left(OHS_1\right)\left(NOPT_{1,3}\right) + \left(OHS_2\right)\left(NOPT_{2,3}\right)$$

$$OHS_4 = \left(OHS_1\right)\left(NOPT_{1,4}\right) + \left(OHS_2\right)\left(NOPT_{2,4}\right)$$

$$OHS_5 = \left(OHS_3\right)\left(NIPD_3\right) + \left(OHS_4\right)\left(NIPD_4\right)$$

Where:

OHS_K = Effective number of system operating hours supported by each activity type K (K=1 thru 5)

SOH_K = Average number of operating hours per system per month at each activity type K (K=1 or 2)

QPV_K = Number of systems per vehicle at activity type K (K=1 or 2)

$NVPO_K$ = Number of vehicles (nominal value) per type K activity (K=1 or 2)

$NOPI_{N,M}$ = Number of the n^{th} type organizational activity per the m^{th} type Intermediate activity

$NIPD_N$ = Number of the n^{th} type Intermediate activity per depot.

$$NSS_1 = \left(QPV_1\right)\left(NVPO_1\right)$$

$$NSS_2 = \left(QPV_2\right)\left(NVPO_2\right)$$

$$NSS_3 = \left(NSS_1\right)\left(NOPI_{1,3}\right) + \left(NSS_2\right)\left(NOPI_{2,3}\right)$$

$$NSS_4 = \left(NSS_1\right)\left(NOPT_{1,4}\right) + \left(NSS_2\right)\left(NOPI_{2,4}\right)$$

$$NSS_5 = \left(NSS_3\right)\left(NIPD_3\right) + \left(NSS_4\right)\left(NIPD_4\right)$$

Where

NSS_K = Effective number of systems supported by each activity type K (K=1 thru 5)

(see above for definition of other terms

$$POI = \frac{(PO3)(OHS_3) + (PO4)(OHS_4)}{OHS_3 + OHS_4}$$

Where:

POI = Portion of total op hrs which are overseas in respect to the depot

PO3 = Portion of type 3 Maintenance activities which are overseas

PO4 = Portion of type 4 Maintenance activities which are overseas

OHS_K = Effective number of operating hours supported by each activity type K

$$SMAPY_{ik} = (CF_i)(QPS_i)(NSS_k)$$

Where:

CV_i = Calibration Frequency of Unit i (Calibrations per year)

QPS_i = Quantity of Unit i per System

NSS_k = Number of systems Supported at Maintenance Activity K

The value of $TRKR_{ik}$ is computed differently depending upon where the item is removed and if it is source coded for discard or repair. The value of $RTKR_{ik}$ is shown in the following matrix.

K	Condemnation Rate of Unit I	Value of $RTKR_{ik}$ if Unit I is Usually Removed at:			
		Not Removed	Org Level	Int Level	Depot
1&2	Not Applicable	CV	0	0	0
3&4	$Cond_{2i} = 1$	0	0	0	0
	$Cond_{2i}$ 1	0	$CVx(1-NRTS_i)$	$CVx(1-NRTS_i)$	0
5	$Cond_{3i} = 1$	0	0	0	0
	$Cond_{3i}$ 1	0	$CVxNRTS_i$	$CVxNRTS_i$	CV

Where:

$$CV = OHS_K \quad QPS_i \quad PUFR_i \quad K3_i$$

and

OHS_k = Operating Hours Supported at Maintenance Activity K

QPS_i = Quantity of Item i per System

$PUFR_i$ = Predicted Unit Failure Rate of Item i

$K3_i$ = Factor to Convert Failure Rate to Maintenance Rate for Unit i

$NRTS_1$ = Fraction of failures reported at the Depot

$COND_{L,i}$ = Fraction of Items received at level L for repair which are concerned. (If value is 1.0 it is assumed unit is source coded for discard).

3.3.2 Cost Category Calculations (Primary)

Direct Labor Costs

$$DL_{kt} = \left(DLR_{kt}\right)\left(DMH_{kt}\right)$$

Where:

DL_{kt} = Direct Labor Cost at Activity k in Year t

DMH_{kt} = Direct Manhours at Activity k in Year t

DLR_{kt} = Direct Labor Rate at Activity k in Year t

a) Direct Manhours

$$DMH_{kt} = \sum_{i=1}^{200} \left\{ (MTKR_{ik})(OPH_t)(RIF_{it})(12) \left[(RTOK_{li})(PLV_l)(MTTR_{li}) + (1-RTOK_{li})(MTTR_{li}) \right] + (SMAPY_{ik})(OPH_t)(MHPSA_{li}) \right\} (RPIF_{it})$$

Where:

$MTKR_{ik}$ = Unscheduled Maintenance Actions per Month for Unit i at Activity k

OPH_t = Fraction of Systems in Operation in Year t

RIF_{it} = Reliability Improvement Function for the i^{th} Item in the t^{th} Year

$RTOK_{li}$ = Retest OK Rate for the i^{th} Item at Maintenance Echelon l

PLV_l = Percent of MTTR Expended on RTOK at Maintenance Echelon l

$MTTR_{li}$ = Mean Time to Repair the i^{th} item at Maintenance Echelon l

$SMAPY_{ik}$ = Scheduled Maintenance Actions per Year for the i^{th} Item at Activity k

$MHPSA_{li}$ = Manhours per Scheduled Maintenance Action for the i^{th} Item at Maintenance Echelon l

$RPIF_i$ = Repair Process Improvement Function for the i^{th} Item in the t^{th} Year

Direct Material Costs

$$DM_{kt} = \sum_{i=1}^{200} 12(MTKR_{ik})(MCPR_{li})(OPH_t)(RIF_{it})$$

Where:

DM_{kt} = Direct Material Costs at the k^{th} Activity in the t^{th} Year

$RTKR_{ik}$ = Unscheduled Maintenance Actions per Month for the i^{th} Item at the k^{th} Activity

$MCPR_{li}$ = Material Cost per Repair for the i^{th} Item at the l^{th} Maintenance Echelon

OPH_t = Fraction of Sytems in Operation in year t

RIF_{it} = Reliability Improvement Function for the i^{th} Item in the t^{th} Year

Overhead Labor Costs

$$OL_{kt} = (DL_{kt})(OLR_k)$$

Where:

OL_{kt} = Overhead Labor Cost at the k^{th} Activity in the t^{th} Year

DL_{kt} = Direct Labor Cost at the k^{th} Activity in the t^{th} Year

OLR_k = Overhead Labor Rate at the k^{th} Activity

General Administrative Costs

$$GA_{kt} = (DL_{kt} + DM_{kt} + OL_{kt})(GAR_k)$$

Where:

GA_{kt} = General Administrative Cost at the k^{th} Activity in the t^{th} Year

DL_{kt} = Direct Labor Cost at the k^{th} Activity in the t^{th} Year

OL_{kt} = Overhead Labor Cost at the k^{th} Activity in the t^{th} Year

DM_{kt} = Direct Material Cost at the k^{th} Activity in the t^{th} Year

GAR_k = General Administrative Rate at the k^{th} Activity

Transportation Cost

$$T_{kt} = 12 \sum_{i=1}^{200} \left[\frac{(RTKR_{ik})(OPH_t)(RIF_{it})}{(NRS_3 + NRS_4)*} \right] \left[(POI)(SCO)(W_i) + (1-POI)(SCC)(W_i) \right]$$

Where:

T_{kt} = Transportation Cost for the k^{th} Activity in the t^{th} Year

$RTKR_{ik}$ = Unscheduled Maintenance Action per Month for i^{th} Item at k^{th} Location

OPH_t = Fraction of Total Systems in Operation in Year t

RIF_{it} = Reliability Improvement Function for the i^{th} Item in the t^{th} Year

POI = Percentage of Overseas Maintenance Stations

SCO = Shipping Cost Overseas in Dollars per Pound per Trip

SCC = Shipping Costs CONUS in Dollars per Pound per Trip

W_i = Weight of i^{th} Item

MRS_k = Number of Maintenance Activities at k^{th} Echelon

*Note: This term used only when k = 3 or 4 and l = 2 also if $RTK_i > 2$ calculation for that item is omitted.

Replenishment Spares Cost

$$RS_{kt} = 12 \sum_{i=1}^{200} (RTKR_{ik})(OPH_t)(RIF_{it})(COND_{li})(PC_{it})$$

Where:

RS_{kt} = Replenishment Spares Cost for the k^{th} Activity in the t^{th} Year

$RTKR_{ik}$ = (see 3.3.7)

OPH_t = (see 3.3.7)

RIF_{it} = (see 3.3.7)

$COND_{li}$ = Condemnation Rate for the i^{th} Item at the l^{th} Level

PC_{it} = Production Cost per Unit of Prime Hardware in the t^{th} Year

Replacement Training Costs

$$RPTC_{kt} = \frac{TNAK_l}{MRS_k} (TR_l)(RTITR_l)$$

Where:

$RPCT_{kt}$ = Replacement Training Cost at Activity k in Year t

$TNAK_1$ = Initial Training Cost for Maintenance Level 1 all Locations

NRS_k = Number of k^{th} Level Maintenance Activities

TR_1 = Annual Manpower Retraining Rate at Maintenance Level 1

$RTITR_1$ = Ratio of Recurring Training Course Cost to Initial Training Course Cost

Support Equipment Maintenance Costs

$$SEMC_{kt} = \sum_{j=1}^{50} (RSE_{jk})(SEMR_j)(OPH_t)(SEMCR_j)(52)$$

Where:

$SEMC_{kt}$ = Support Equipment Maintenance Cost at the k^{th} Activity in the t^{th} Year

RSE_{jk} = Demand Hours per Week for Test Equipment j at Activity k

$SEMR_j$ = Maintenance Rate of Support Equipment j (Maintenance Actions per Million Operating Hours)

OPH_t = Fraction of Total Systems in Operation in the t^{th} Year

$SEMCR_j$ = Maintenance Cost Rate of Support Equipment j (Dollars per Maintenance Action)

Maintenance Management Data Cost

$$MMDC_t = 12 \times \sum_{k=1}^{5} \sum_{i=1}^{200} RTKR_{ik}(OPH_t)(RIF_{it})(NRS_k)(DLR_1)(MRF + SR + TRF)$$

Where:

$MMDC_t$ = Maintenance Management Data Costs in the t^{th} Year

$RTKR_{ik}$ = (see 3.3.7)

OPH_t = (see 3.3.7)

RIF_{it} = (see 3.3.7)

NRS_k = (se 3.3.7)

DLR_1 = (same as DLR_{kt} - see 3.3.3)

MRF = Average Manhours per Maintenance Action for Maintenance Records

SR = Average Manhours per Maintenance Action for Completing Supply Transaction Records

TRF = Average Manhours per Maintenance Action for Completing Transportation Forms

Inventory Management

$$IMC_t = (RAC)(NPTA + NATA) + NPSB(NRS_3 + NRS_4)(SA)$$

Where:

IMC_t = Inventory Management Cost in the t^{th} Year

RAC = Recurring Yearly Inventory Management Cost to Maintain an Assembly in the Wholesale System

NPTA = Number of New Part Types to be Introduced into the Inventory

NATA = Number of New Assembly Types to be Introduced into the Inventory

NPSB = Number of Part Types Stocked at Base

NRS_k = (see 3.3.9)

SA = Annual Cost per Base-stocked Item per Base Inventory Location

Warranty Provisions

The model contains the capability of considering units which may be under a maintenance warranty for all or part of the cost study period. For these units, the warranty cost by year, WCI_{it}, is put with the unit data. Prior to the cost computations of direct labor, direct materiel, transportation, replenishment spares and maintenance management for unit i in year t, the value of WCI_{it} is checked. If its value is greater than zero, the cost category calculation is skipped and the warranty cost of i is summed into the warranty cost category as follows:

$$WC_{5t} = \sum_{i=1}^{200} WCI_{it}$$

Cost Summation Calculations

All of the above cost categories applicable to a specific maintenance activity, i.e. those which include the index k, are computed on a per activity basis. Subsequently the cost per activity is multiplied by the number of each type activity to get the total cost. In doing this, the variable name is changed by adding a prefix T. For example:

$$TDL_{kt} = (DL_{kt})(NRS_k)$$

and

$$TDM_{kt} = (DM_{kt})(NRS_k)$$

3.3.3 Cost Category Calculations (Detailed Data not Available)

When detailed input maintenance cost data is not available, the model reverts to a summary computation of maintenance activity costs which requires only eight items of input data. These items are defined as follows and are input on the 631 card:

ODL(1) = organizational direct labor cost per maintenance activity per year assuming all equipment is deployed and mature.

ODL(2) = intermediate direct labor cost per maintenance activity per year assuming all equipment is deployed and mature.

ODL(3) = depot direct labor cost per maintenace activity per year assuming all equipment is deployed and mature.

ODM(1) = intermediate direct material cost per maintenance activity per year assuming all equipment is deployed and mature.

ODM(2) = depot direct material cost per maintenance activity per year assuming all equipment is deployed and mature.

ORS(1) = intermediate spares replenishment cost per maintenance activity per year assuming all equipment is deployed and mature.

ORS(2) = depot spares replenishment cost per maintenance activity per year assuming all equipment is deployed and mature.

OWC = warranty cost to the government per contractor maintenance activity (depot) per year assuming all equipment is deployed and mature.

The model uses these inputs and model supplied default values to compute various elements of costs at organizational, intermediate, and depot maintenance levels. At the organizational level, the following five costs are computed:

1. DL_{kj} = organizational direct labor cost per type k maintenance activity in year j

$= (OPH_j * RIFC_j * RPIFC_j) * ODL(1)$, $k = 1,2$; $j = 1,2,\ldots, NY$

where OPH_j = fraction of total systems that are deployed in year j,

$RIFC_j$ = the default value of the reliability improvement function for year j,

$RPIFC_j$ = the default value of the repair process improvement function for year j.

2. OL_{kj} = organizational overhead labor cost per type k maintenance activity in year j

$= .75 * DL_{kj}$, $k = 1,2$; $j = 1,2,\ldots, NY$.

3. GA_{kj} = organizational general and administrative cost per type k maintenance activity in year j

$= .5 * DL_{kj}$, $k = 1,2$; $j = 1,2,\ldots, NY$.

4. $RPTC_{kj}$ = organizational replacement training cost per type k maintenance activity in year j

$= .05 * DL_{kj}$, $k = 1,2$; $j =1,2,\ldots, NY$.

5. $SEMC_{kj}$ = organizational support equipment maintenance cost per type k activity in year j

$= .01 * DL_{kj}$, $k = 1,2$; $j = 1,2,\ldots, NY$.

The constant coefficients, .75, .5, .05, and .01 used in calculating OL_{kj}, GA_{kj}, $RPTC_{kj}$, and $SEMC_{kj}$, respectively, $j = 1,2,\ldots,$ NY, are simply rough estimates whose accuracy should be adequate in view of the level of detail of the maintenance cost calculation. Unless particular values for the coefficients OPH_j, $RIFC_j$, and $RPIFC_j$, $j = 1,2,\ldots, NY$, are input by the user a default value of 1.0 is used for each of them.

At the intermediate level, this summary maintenance cost format reflects the following eight cost elements:

1. DL_{kj} = intermediate direct labor cost per type k maintenance activity in year j

   = $(OPH_j * RIFC_j * RPIFC_j) * ODL(2)$, k = 3,4; j = 1,2, NY.

2. OL_{kj} = intermediate overhead labor cost per type k maintenance activity in year j

   = $.75 * DL_{kj}$ k = 3,4; j = 1,2,..., NY.

3. GA_{kj} = intermediate general and administrative cost per type k maintenance activity in year j

   = $.5 * DL_{kj}$ k = 3,4; j = 1,2,..., NY.

4. DM_{kj} = intermediate direct material cost per type k maintenance activity in year j

   = $(OPH_j * RIFC_j) * ODM(1)$, k = 3,4; j = 1,2,..., NY.

5. T_{kj} = intermediate level transportation cost per type k maintenance activity in year j

   = $.01 * (DL_{kj} + DM_{kj})$, k = 3,4; j = 1,2,..., NY.

6. RS_{kj} = intermediate spares replenishment cost per type k maintenance activity in year j

   = $(OPH_j * RIFC_j) * ORS(1)$, k = 3,4; j = 1,2,..., NY.

7. $RPTC_{kj}$ = intermediate replacement training cost per type k maintenance activity in year j

   = $.05 * DL_{kj}$, k = 3,4; j = 1,2,..., NY.

8. $SEMC_{kj}$ = intermediate support equipment maintenance cost per type k maintenance activity in year j

   = $.01 * DL_{kj}$, k = 3,4; j = 1,2,..., NY.

At the depot level, the summary maintenance cost format reflects the following nine cost elements:

1. DL_{5j} = depot direct labor cost per maintenance activity in year j

= $(OPH_j * RIFC_j * RPIFC_j) * ODL(3)$, j = 1,2,..., NY.

2. DM_{5j} = depot direct material cost per maintenance activity in year j, j = 1,2,..., NY.

= $(OPH_j * RIFC_j) * ODM(2)$, j = 1,2,..., NY.

3. OL_{5j} = depot overhead labor cost per maintenance activity in year j

= $.75 * DL_{5j}$, j = 1,2,..., NY.

4. GA_{5j} = depot general and administrative cost per maintenance activity in year j

= $.50 * DL_{5j}$, j = 1,2,..., NY.

5. T_{5j} = depot level transportation cost per maintenance activity in year j

= $.01 * (DL_{5j} + DM_{5j})$, j = 1,2,..., NY.

6. RS_{5j} = depot spares replenishment cost per maintenance activity in year j

= $(OPH_j * RIFC_j) * ORS(2)$, j = 1,2,..., NY.

7. WC_{5j} = warranty cost to the government per contractor maintenance activity (depot) in year j

= $(OPH_j * RIFC_j * RPIFC_j) * OWC$, j = 1,2,..., NY.

8. $RPTC_{5j}$ = depot replacement training cost per maintenance activity in year j

= $.05 * DL_{5j}$, j = 1,2,..., NY.

9. $SEMC_{5j}$ = depot support equipment maintenance cost per maintenance activity in year j

= $.01 * DL_{5j}$, j = 1,2,..., NY.

APPENDIX L

RCA PRICE AND PRICE L SAMPLE OUTPUTS

RCA PRICE AND PRICE L SAMPLE OUTPUTS

Sample outputs for the RCA proprietary PRICE development and production cost estimating model and the PRICE L life cycle cost model are provided in Figures L-1 and L-2, respectively.

In Figure L-1, development and production costs are displayed according to engineering and manufacturing cost categories. In Figure L-2, support costs are displayed for seven cost categories including equipment, support equipment, manpower, supply, supply administration, contractor support, and other costs. Reliability and maintainability data such as mean time between failure, and module and LRU mean time to repair, are also displayed.

```
AIRBORNE RADAR  MIL-SPEC   STANDARD PRICE RUN      JULY 14,1976

INPUT DATA
QTY       250. PROTOS    10.0 WT     113.000 VOL      2.500 MODE      1.
QTYSYS      1. INTEGE   1.000 INTEGS   1.000 AMULTE 100.00% AMULTM 100.00%

MECH/STRUCT
WS      29.000 MCPLXS   5.600 PRODS    0.000 NEWST    0.700 DESRPS   0.200

ELECTRONICS
USEVOL   0.840 MCPLXE   7.900 PPODE    0.000 NEWEL    0.300 DESRPE   0.400
PWR      0.000 CMPNTS      0. CMPID    0.000 PWRFAC   1.080 CMPEFF -10.000

ENGINEERING
ENMTHS     6.0 ENMTHF    15.0 ENMTHT    25.0 ECMPLX   0.000 PRNF     0.000

PRODUCTION
PRMTHS    30.0 PRMTHF    66.0 LCURVE   0.900 ECNE     0.000 ECNS     0.000

GLOBAL
YEAR     1976. ESC      0.00% PROJCT   1.000 DATA     1.000 TLGTST   1.000
PLATFM   1.800 SYSTEM   1.000 PPROJ    1.000 PDATA    1.000 PTLGTS    1.00

PROGRAM COST            DEVELOPMENT        PRODUCTION         TOTAL COST
ENGINEERING
 DRAFTING                      160.               40.               200.
 DESIGN                        592.              120.               712.
 SYSTEMS                        97.                0.                97.
 PROJ MGMT                     180.              576.               756.
 DATA                           50.               27.                77.
  SUBTOTAL(ENG)               1078.              763.              1841.

MANUFACTURING
 PRODUCTION                      0.            10153.             10153.
 PROTOTYPE                    1174.                0.              1174.
 TOOL-TEST EQ                  150.              264.               415.
  SUBTOTAL(MFG)               1324.            10417.             11742.

  TOTAL COST                  2402.            11181.             13583.

VOL      2.500 AVCOST     40.61 TOTAL AV PROD COST   44.72 LCURVE  0.900
WT     113.000 ECNE       0.091 ECNS      0.026 DESRPE 0.400 DESRPS  0.200

MECH/STRUCT
WS      29.000 WSCF      11.600 MECID     0.000 PRODS  4.226 MCPLXS  5.600
ELECTRONICS
WE      84.000 WECF      40.000 CMPID     0.000 PRODE  4.378 MCPLXE  7.900
PWR    241.271 CMPNTS    6014.                  PWRFAC 1.080 CMPEFF-10.000

SCHEDULES
ENMTHS   6.000 ENMTHF    15.000 ENMTHT 25.000 ECMPLX 1.210 PRNF     0.204
PRMTHS  30.000 PRMTHF    66.000 AVER. PROD RATE PER MONTH           6.944

COST RANGES             DEVELOPMENT        PRODUCTION         TOTAL COST
      FROM                    2120.             9463.             11583.
      CENTER                  2402.            11181.             13583.
      TO                      2796.            13545.             16341.
```

Figure L-1. BASIC PRICE PRODUCTION-DEVELOPMENT COST OUTPUT FORMAT

```
                         PRICE LIFE CYCLE COST

POWER AMP                                                    LCICHADH

INPUT DATA

R&M DATA
  MTBF          554, MTTR-LRU           1,5  MTTR-MOD        3,0

DEPLOYMENT
  EQUIPS        240, ORGANIZATION      15,   INTERMEDIATE   15,  DEPOT   1,
  LRUS/EQUIP      2, MODS/LRU          31,   PARTS/LRU     141,

EMPLOYMENT
  SUPPORT PERIOD          15,                HRS/MON        73,0  UTF    0,100

GLOBAL
  EQUSUP        240, ORGSUP            15,   INTSUP         15,  DEPSUP  1,
  ESC             0, LRU FAIL ALLOW     0,

MAINTENANCE CONCEPT  10
LRU REPAIR TO PIECE PART AT ORGANIZATION,

PROGRAM COST          DEVELOPMENT    PRODUCTION          SUPPORT         TOTAL

  EQUIPMENT                 779,         11363,               0,        12142,
  SUPPORT EQUIP               0,          2047,            3071,         5118,
  MANPOWER                    0,             0,             651,          651,
  SUPPLY                      0,          1386,             626,         2011,
  SUPPLY ADM,                 0,            10,             152,          162,
  CONTRACTOR SUPPORT          0,             0,               0,            0,
  OTHER                       0,             0,               1,            1,

      TOTAL COST            779,         14806,            4501,        20086,

AVAILABILITY
INHERENT                   0,9891  OPERATIONAL                         0,9893

SUPPORT EQUIPMENT          ORG                 INT             DEPOT
NO,                        15,                 0,              0,
UTILIZATION                 0,412              0,0             0,0

SUPPLY                     UNITS               MODULES         PARTS
INITIAL, PER TYPE          0,                  15,             41,
BALANCE CONSUMED           0,0                 0,0             39,363

COST/EFFECTIVNESS LIST (%)
10*    100,0  6*    104,3  5*    122,1  7*    122,9  8*    127,4 17*    133,1
 9*    134,7 14*    142,4 12*    156,3 18*    156,5 11*    157,0 13*    160,3
16*    171,1 19*    194,1  2*    194,3  3*    223,1  4*    238,5 15*    302,4
 1*   1430,0
```

Figure L-2. BASIC PRICE LIFE CYCLE COST OUTPUT FORMAT