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A SUMMARY AND ANALYSIS OF THE INITIAL APPLICATION OF LIFE--ETC(U)

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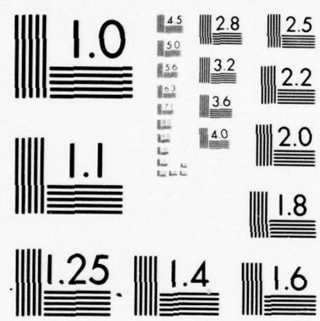

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Lt Col, USAF

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The first USAF major system acquisition program in which there was explicit consideration given to LCC was the A-X/A-10 Close Air Support Aircraft competition. LCC considerations were quantified using an operating and support (O&S) cost model developed under Project ABLE (Acquisition Based upon consideration of Logistics Effects). Air Force objectives in applying the O&S cost model were: (1) to encourage contractor consideration of operating and support costs in system design, (2) to aid in source selection, (3) to aid in evaluation of engineering change proposals, and (4) to aid in determining the magnitude of award fee (if any) to be granted the contractor. This research has focused on the degree to which these objectives were actually met, problems encountered in meeting them, and suggestions for improving future applications of O&S cost models in LCC programs. Several major deficiencies were discovered in data use and model application that cast serious doubt on the efficacy of this first O&S cost model application and require amelioration to avoid repetition of problems in future acquisition programs.

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A SUMMARY AND ANALYSIS OF THE INITIAL APPLICATION OF LIFE CYCLE COSTING TECHNIQUES TO A MAJOR WEAPON SYSTEM ACQUISITION

Archie C. Bell, GS-11
Daniel P. Turney, Captain, USAF

LSSR 35-78B

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A SUMMARY AND ANALYSIS OF THE INITIAL APPLICATION OF LIFE CYCLE COSTING TECHNIQUES TO A MAJOR WEAPON SYSTEM ACQUISITION

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

Archie C. Bell[redacted]
GS-11

Daniel P. Turney, BS
Captain, USAF

Sept[redacted]978

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This thesis, written by

Mr. Archie C. Bell

and

Captain Daniel P. Turney

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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TABLE OF CONTENTS

Chapter | Page

Page

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Problem Statement

This thesis resulted from problems identified by the Joint Air Force Logistics Command/Air Force Systems Command (AFLC/AFSC) Commanders' Working Group on Life Cycle Costing (LCC) (35). The first United States Air Force major system acquisition program in which there was explicit consideration given to LCC was the A-X/A-10 Close Air Support Aircraft competition (27; 28). The A-X/A-10 competition addressed LCC considerations via an operating and support (O&S) cost model which estimated "operating and support costs associated with each proposed design [28:3]." Proponents of LCC feel that LCC techniques, when applied early enough and over an adequate period of time, will result in the purchase of more reliable and cost effective systems (38:i). To aid future users of O&S cost models, there was a need to assess the effectiveness of the initial application of an O&S cost model to major systems acquisitions.

Background and Justification

Overview. Within the past decade, the obligation of funds by Air Force planners has become a subject receiving ever increasing scrutiny by budget analysts. This is due, in part, to the reduction of the total defense budget from 46 percent of the Federal Budget in 1960 to 26 percent in 1977. Concurrent with the budget reduction has been a significant increase in the total cost of acquiring and supporting new weapons systems (23:16). Analysis of total major system costs has revealed that only 40 percent of the total dollars expended can be traced to research and acquisition procurements. The remaining 60 percent is absorbed in O&S costs (28). This phenomenon was recently summarized by General Bryce Poe, II, in a speech given to the American Defense Preparedness Association:

> O&S costs [have begun] to significantly reduce the dollars available for development of new systems . . . the result [is] clear. Cut operating and support costs or forget about development and acquisition of the new weapons required to meet an ever more serious threat [23:16].

Life cycle costing. A recent advancement in the Air Force acquisition process has been the application of LCC techniques during the early stages of the process. LCC is an attempt to determine the overall costs associated with buying and owning a major system so that the most reliable and maintainable system can be acquired (28). The application of LCC to the procurement process addresses three cost element categories:

> 1. Acquisition Costs—the sum of the unit prices for the line items of hardware, data, and services being procured.
> 2. Initial Logistics Costs—the one-time logistic costs which are identifiable and would be incurred by the Government for the item being procured.

3. Recurring Costs—those costs incurred by the Government in connection with the operation, maintenance, and management of the item being procured [8:1-4].

LCC was first applied to the procurement process with the purchase of tires for the F-100 aircraft (27; 28).

Operation and support cost model. The first application of LCC to a major system acquisition—the A-X/A-10 Close Air Support Aircraft—utilized an O&S cost model. The value of this technique is its ability to quantify the contribution of reliability and maintainability (R&M) parameters in order to effect a design that would reduce overall logistics costs without adversely affecting the desired performance characteristics (20:1; 35:2).

The model consists of a set of mathematical equations addressing selected cost elements which, when totaled, yield an approximation of the total O&S costs for the weapons system over a specified period of time (34:2). These elements are driven by maintenance data inputs provided via the D056 Product Performance Collection System, a product of AFM 66-1, Volume II, *Maintenance Management*, and AFM 66-267, *Maintenance Data Collection System* (5).

The methods utilized to compute O&S costs are presented below. R&M factor conversion is accomplished via standard formulae, which combine the many facets of R&M costs into "logistics effect" dollar figures (8:2-4). The general formula is:

$$LE = LE_S + LE_R + LE_L + LE_E$$

where:

LE = Total logistic effect,

LE_S = Dollar value of pipeline spares,

LE_R = Dollar value of base and depot level repairs,

LE_L = Dollar value of all other logistics costs,

LE_E = Inputed dollar value of the two effectiveness attributes, system availability and system dependability [16:2].

The competing contractors apply the specific formulae to obtain cost predictions called Targeted Logistics Effects (TLE). Source selection can be facilitated through comparison of competing contractors' TLEs. After system production and deployment, the government uses actual data on logistics costs in the same set of formulae to develop Measured Logistics Effects (MLE). A comparison can then be made to determine the amount of incentive fee, if any, to be awarded to the contractor. This is accomplished with the following formulae:

> Bonus = (SR) (TLE-MLE) if MLE < TLE
>
> Penalty = (SR) (MLE-TLE) if TLE < MLE . . .
>
> . . . where SR is a sharing ratio, i.e., percentages of bonus/penalty to be born by the contractor and the government [16:7].

There are two factors which insure that the contractor computes TLEs as accurately as he is able. First, the TLEs are computed during the competitive phase of the acquisition process. Consequently, the contractors incentive is to keep the TLEs as low as possible. Second, the TLEs will eventually be compared to the MLEs to determine the incentive fee, which insures the contractor will not make too low an estimate of his TLEs (16:2-6).

Application to A-X/A-10. The O&S cost model used in the A-X prime contractor competition was developed in Project ABLE—Acquisition Based upon consideration of Logistics Effects (20). Table 1 identifies the areas addressed by each MLE in the Project ABLE model. This model, dubbed "Strawman," was incorporated into the Statement of Work (SOW) portion of the Request for Proposal (RFP) (3) which was transmitted to the competing contractors, Northrop and Fairchild-Republic, during the Competitive Prototype Phase (CPP) of the A-X competition (8; 37). The United States Air Force's planned use of the model was expressed by the Operations Analysis Office, Headquarters, Air Force Logistics Command as follows:

> . . . the Air Force's intention to use this model, or some similar model, to assess the supportability of their hardware, and further, the relative supportability will be one of the criteria on which the production contract will be based [5:2].

The contractor was tasked with exercising the prediction mode (TLE) in two phases. The first values were to represent TLEs after reliability and maintainability (R&M) of the Line Replaceable Units (LRUs) had matured. Secondly, value estimates for 5000 total flying hours were required. The latter was expected to reflect "early learning curve"

TABLE 1

PROJECT ABLE—MEASURED LOGISTICS EFFECTS

MLE_1	Dollar cost of initially procured and subsequently replaced LRUs over the operational life of the aircraft.
MLE_2	Dollar cost of "off-equipment" maintenance on all LRUs removed from the total fleet of aircraft during the operational life of the system.
MLE_3	Dollar cost of "on-equipment" maintenance on all LRUs serviced during: preflight, postflight, and phase inspections and time-change removals, for the total operational life of the system.
MLE_4	Dollar cost of "new item" inventory incident to spares provisioning.
MLE_5	Acquisition cost of Ground Support Equipment at all levels of maintenance.
MLE_6	Acquisition cost of all technical data.
MLE_7	Acquisition cost of training equipment—excluding maintenance.
MLE_8	Acquisition cost of all maintenance training.
MLE_9	Dollar cost of total fuel consumption during the operational life of the aircraft.

(5:14-21)

characteristics, while the former would produce a considerably lower cost per flying hour figure (5:3). The contracting office solicited, "the contractors' best efforts . . . to identify the preferred designs of the A-X configuration items [5:14]."

> Under this methodology, the contractor's TLE is considered with acquisition cost in making the production source selection decision, and the TLE of the bidder who wins that contract becomes contractually binding [5:4].

After Fairchild-Republic and Northrop Corporation received the "Strawman" model, the government requested and received contractor recommendations on how to improve the O&S cost model. The final version of the A-X/A-10 O&S cost model consists of thirteen separate cost elements (38:10). The definitions of these elements are listed in Table 2. Each cost element was determined by either application of a formula or application of straightforward accounting procedures (8:D-10).

<u>Results</u>. The results obtained from the application of the O&S cost model to the A-10 program were to serve as the basis for the objective evaluation of the contractors' success in reducing O&S costs (7:2). There were three major purposes to be fulfilled by this evaluation:

1. To serve as a source selection criterion;

2. To aid in evaluation of engineering change proposals (ECPs) with respect to their impact on O&S costs;

3. To attain a basis for the determination of an award fee (7:2).

TABLE 2

A-X O&S COST TLEs/MLEs

TLE_1/MLE_1	Initial and replenishment spares for LRUs
TLE_2/MLE_2	"Off-equipment" maintenance of all LRUs
TLE_3/MLE_3	"On-equipment" maintenance of all systems
TLE_4/MLE_4	Ineffective "off-equipment" maintenance
TLE_5/MLE_5	New item inventory management
TLE_6/MLE_6	Acquisition of Aerospace Ground Equipment (AGE)[1]
TLE_7/MLE_7	Acquisition of training equipment and its ancillary support AGE
TLE_8/MLE_8	Acquisition cost of operational phase data
TLE_9/MLE_9	Type I training
TLE_{10}/MLE_{10}	Fuel consumption
TLE_{11}/MLE_{11}	Spare whole engines and modules (base supply)
TLE_{12}/MLE_{12}	"Off-equipment" maintenance for engines
TLE_{13}/MLE_{13}	Spare whole engines and modules (depot)

[1]AGE is currently referred to as Ground Support Equipment (GSE).

(7:D-2)

The values used for TLE computations were derived from either program constants, government furnished values, or historical comparisons from similar weapons systems (7:3). The values of TLEs were adjusted after the validation phase to account for differences in the predicted growth values (learning curve) associated with maintenance (7:5). MLE values were computed using actual data compiled over the first 5000 hours of operational flying. The first four MLEs were computer augmented calculations and the remaining nine MLEs are manually computed (7:6-7).

Objectives

This study of the initial application of an O&S cost model to a major weapon system acquisition will provide future users insights into model utilization. To accomplish this task, the following objectives were established:

1. Determine if the Air Force objectives were met in the initial application of the O&S cost model.

2. Investigate methods of application and determine if improvements are warranted.

Research Questions

To fulfill the objectives of this research, the following research questions were postulated:

1. What were the Air Force's objectives in applying the O&S cost model to the A-X/A-10 acquisition cycle?

2. Was the data required by MLEs 1-4 available from the designated data retrieval system—D056?

3. Could a valid comparison be made between the TLEs submitted by Northrop and Fairchild-Republic?

4. Could a valid comparison be made between the TLEs submitted by Fairchild and the MLEs computed by the Air Force?

5. Were the objectives established by the Air Force accomplished by applying the O&S cost model?

Scope

This research effort was limited to investigating the first application of an O&S cost model to weapon system acquisition. Specifically, the application of the model to the A-10 was investigated. Documentation of the investigation is in the form of a case study of the A-10 application and includes a summary of findings and recommendations for future application of the O&S cost model.

Chapter 2

METHODOLOGY

Introduction

This chapter describes the methods by which the research questions were answered. The primary assumption made concerning this effort was that the O&S cost model itself is valid. This assumption was based on a validation study conducted by the United States Air Force Academy (USAFA) (7). The areas addressed by the research questions were: Air Force objectives in using the model; methods used in applying the model; and data availability. The questions were answered based upon two sources of information: interviews and documentation.

Interviews were conducted with Air Force and contractor personnel who were directly involved with application of the O&S cost model to the A-X/A-10 program. Researchers visited the A-10 SPO, Air Force Acquisition Logistics Division (AFALD), Air Force Business Research Management Center (AFBRMC), Sacramento Air Logistics Center (SM/ALC), Fairchild-Republic Company, and Northrop Corporation to conduct these interviews.

The document research included a thorough examination of all available documents pertaining to the application of the O&S cost model to the A-X/A-10 program, including SOWs, Decision Coordinating Papers (DCPs), and RFPs. Additionally, documents obtained from the contractors pertaining to the O&S cost model were reviewed.

An overview of the areas of research addressed by this methodology is illustrated in Figure 1. As shown in the figure, comparative analysis of the results of application of the O&S cost model may be favorable or unfavorable. If favorable, no modifications are required. If unfavorable, several areas must be investigated. This research addressed the possibilities that: (1) the model was applied incorrectly; (2) data required in the model was unavailable; and/or (3) the objectives set for model usage were unrealistic.

Air Force Objectives in Applying an O&S Cost Model

Effectiveness is a measure of outputs against accomplishment of goals or objectives (26). In order to assess the effectiveness of this application of an O&S cost model, it was necessary to determine exactly what objectives were established by the Air Force to be met by applying the model. To make this determination, a representative from the research team discussed these objectives with A-10 SPO personnel, and personnel from AFALD. Representatives from Fairchild-Republic Company and Northrop Corporation were asked what they perceived to be the Air Force objectives in

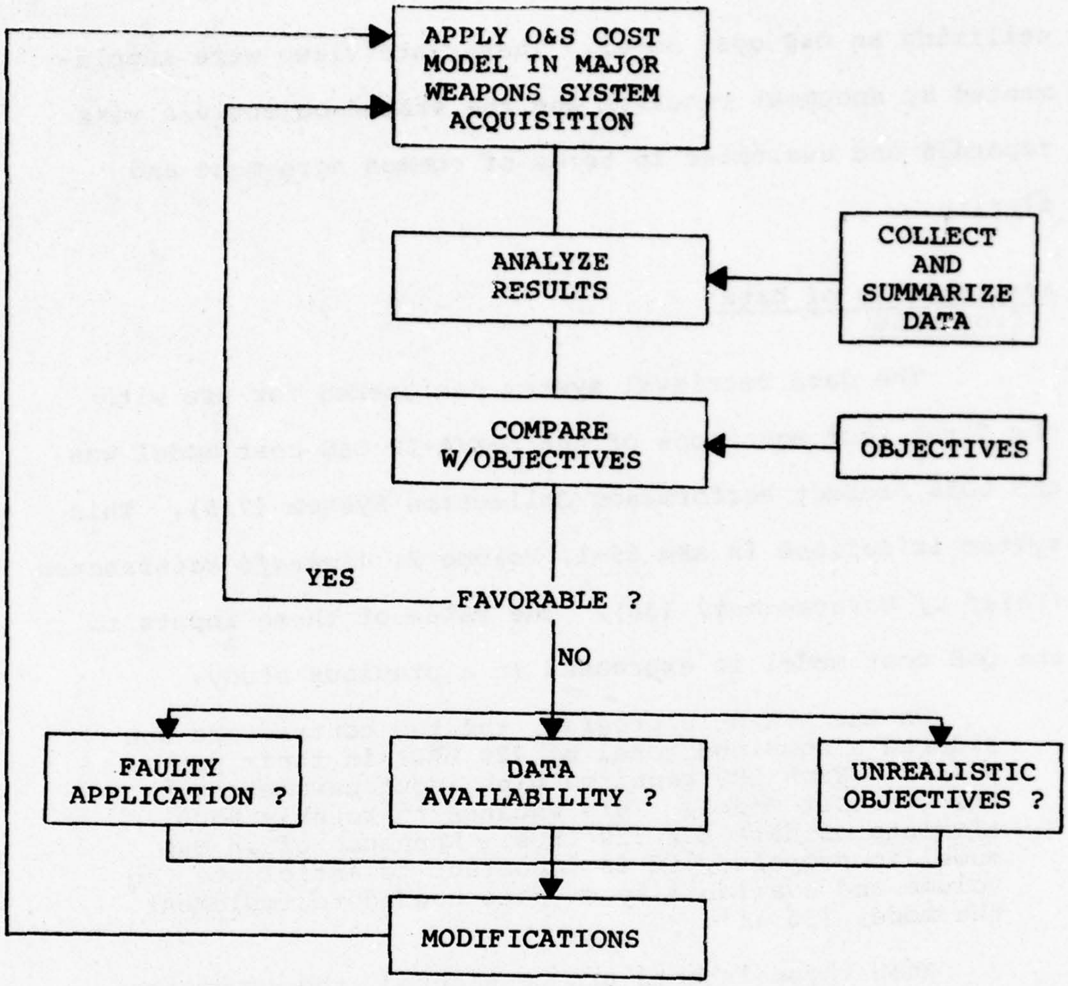


Figure 1

Areas Addressed in Methodology

utilizing an O&S cost model. These interviews were supplemented by document research and the stated objectives were recorded and evaluated in terms of common agreement and clarity.

Availability of Data from D056

The data retrieval system designated for use with the first four equations of the A-X/A-10 O&S cost model was the D056 Product Performance Collection System (7:E). This system is defined in AFM 66-1, Volume 2, *Aircraft Maintenance (Chief of Maintenance)* (36). The value of these inputs to the O&S cost model is expressed in a previous study:

> On the A-X/A-10 program, the two contractors considered a combined total of 720 LRUs in their proposals. Each LRU required nine input parameters in the O&S cost model. This equates to roughly 6500 elements of data for 720 LRUs. When use of an O&S model is proposed, it is important to anticipate the volume and availability of data needed to implement the model [35:11].

When these factors are considered, the importance of a data retrieval system compatible with model requirements becomes apparent.

To determine whether or not the data requirements for the model were available from D056, the research team examined the data elements required in the model and compared them to the data elements available from D056. The basis for answering research question 2 on the data availability affirmatively was whether or not data could be obtained from this system and applied directly to the model.

Faulty Application

Validity of comparisons of contractors' TLEs. To test the validity of comparisons between contractor TLEs, the research team examined the techniques used by Fairchild-Republic and Northrop in exercising the O&S model. Specifically, the data base and methods used in LRU selection must have been consistent between the contractors. Consistency in these areas is essential for valid comparisons between the TLE computations of Fairchild and Northrop. This concept is illustrated in Figure 2. The following criteria were used to determine whether or not consistency existed in the areas of data and application techniques:

1. The Air Force must have used the same data base in providing data to Northrop and to Fairchild for TLE computations.

2. The same criteria must have been used by both contractors in selecting LRUs.

If the contractor did not draw upon the same data base for calculating TLEs, any attempt at comparing these TLE values would not be valid. This was the basis for criterion number 1 above.

The use of the same criteria for LRU selection is essential to insure that TLE comparisons between contractors encompass the same baseline. For example, the contractors may designate LRUs differently so long as the LRUs selected account for the total O&S costs for the entire aircraft (7:7-8).

IF

$DATA_F \approx DATA_N$

AND

$LRU\ DETERMINATION_F \approx LRU\ DETERMINATION_N$

THEN:

TLE COMPARISON → VALID

IF

$DATA_F \not\approx DATA_N$

AND/OR

$LRU\ DETERMINATION_F \not\approx LRU\ DETERMINATION_N$

THEN:

TLE COMPARISON → INVALID

Where:

F = Fairchild
N = Northrop
≈ = Consistent
DATA = Data Base
LRU DETERMINATION = Criteria used to select LRUs

Figure 2

Comparison of TLEs Submitted by Contractors

If the entire aircraft is not accounted for, the contractors may decide to use the criterion of encompassing high cost drivers using the same dollar cutoff. Another option might be for the contractors to select only those LRUs related to a specific subsystem of the aircraft, such as avionics. These examples serve to illustrate that innumerable criteria are available for LRU selection. It should also be apparent that significant problems would be encountered if Fairchild chose to evaluate only those LRUs associated with the avionics package while Northrop decided to evaluate high cost drivers. This explanation provided the basis for the establishment of criterion number 2. Violation of either criterion will result in the inability to make a valid TLE to TLE comparison. The elements of this investigation were provided via interviews with the contractors and by document research.

<u>Validity of comparisons between TLEs and MLEs</u>. There must have been consistency between the application of the O&S cost model in TLE computations and MLE computations. Otherwise, comparisons between predicted costs (TLEs) and actual costs (MLEs) would not be valid. The following criteria were used to determine whether or not consistency existed in the areas of data and application techniques:

1. The same components (LRUs) must have been evaluated by the contractor and the Air Force.

2. Data for the computation of the TLEs and MLEs had to be sufficient to make a valid projection of O&S costs for the LRUs being evaluated.

3. The methods used to develop the O&S cost projection from TLEs had to be the same methods used to develop O&S cost predictions from MLEs.

A related study on the application of the O&S cost model states that the LRUs used in the model must either be the same or must account for the total O&S costs of the entire aircraft (13:7-8). This was the basis for the establishment of criterion number 1. All data necessary to exercise the model had to be supplied to the contractor by the Air Force. Failure to furnish reliable historical estimates would result in inaccurate TLE computations, unless such data could be obtained from other sources. By the same token, the absence of reliable A-10 maintenance data would result in inaccurate MLE computations.

If either TLE or MLE computations were of questionable accuracy, any comparison between the two would be inconclusive. This was the basis for criterion number 2.

Finally, it must be firmly established that both Fairchild and the Air Force applied the O&S cost model in the same manner (i.e., in accordance with instructions provided in the SOW). Any errors in application methods would result in the inability to make a valid comparison between TLEs and MLEs. Hence, the establishment of criterion number 3. Violation of any one of these criteria would result in the inability to make a valid TLE to MLE comparison. Application of these three criteria is illustrated in Figure 3. The elements of this investigation were provided via interviews with the contractors and by document research.

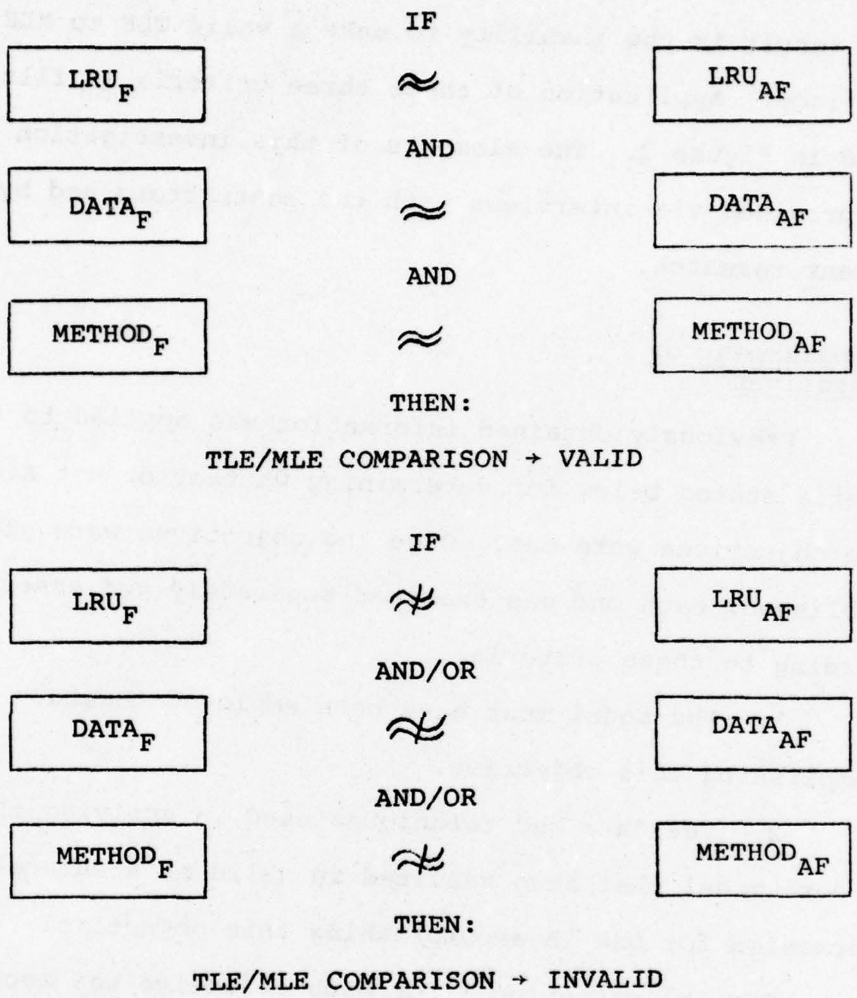
Accomplishment of Objectives

Previously obtained information was applied to the criteria stated below for determining whether or not Air Force objectives were met. Once the objectives were clearly established, each one was examined separately and assessed according to these criteria:

1. The model must have been employed toward accomplishing this objective.

2. The data and techniques used in applying the O&S cost model must have resulted in valid or accurate information for use in accomplishing this objective.

Testing criterion 1 for each objective was accomplished through discussion with the A-10 SPO supplemented by document research. Criterion 2 was tested from previous information in this thesis concerning validity of the comparisons of TLEs/MLEs. An objective was considered to have been fulfilled only if both criteria were met.



Where:

F = Fairchild
AF = Air Force
≈ = Consistent

DATA = Data used for O&S cost predictions
LRU = Line Replaceable Units
METHOD = Method of Application

Figure 3

Comparison of Contractor TLEs and Air Force MLEs

Interviews

The aforementioned interviews were conducted in a nonstructured fashion. Answers were solicited for the questions presented in Appendices A, B, and C.

Chapter 3

AIR FORCE OBJECTIVES IN MODEL APPLICATION

Introduction

This chapter addresses the question of what the Air Force's objectives were in using an O&S cost model in the A-X/A-10 acquisition process. The information provided herein was obtained from a number of sources including personal interviews with the A-10 SPO director and representatives from Fairchild-Republic Company and Northrop Corporation. Determination of objectives was evaluated only in terms of common agreement and clarity. Whether or not these objectives were met will be addressed in Chapter 7 of this thesis.

Overall Objective

The overall objective of any LCC application technique is to minimize the overall costs of owning and operating a weapon system. Early application of LCC insures that this objective will be considered in the original design of the system (38). An indepth study of Project ABLE confirmed that this was the primary function of O&S cost model application. A supplement of the Project states:

> One of the major objectives of Project ABLE is to cause a new system's development and production contractor(s) to give careful and balanced consideration to logistics implications during the design process [17:2].

This is reiterated in another supplement of the same project: "The Project ABLE objective is not to forecast true costs but to create the appropriate motivation, neither too large or too small, to make the system better sooner [16:2]." This objective was transmitted to the contractors through the Request For Proposal (RFP), F33657-70-R-0896, a copy of which was provided each competing contractor. A reference document in the RFP states that:

> the model provides the contractor a means of making design and management tradeoffs in the interest of minimizing (within certain constraints) the total cost to the Government of A-X ownership [2].

Thus, the Air Force's overall objective of motivating the contractors to design a weapon system that will do the best job with the least overall cost to own and operate is clear. It has also been established that this objective was transmitted to the contractors. The question still remained as to the contractor's understanding of this objective.

Mr. D. D. Gregor, one of Northrop's life cycle costing experts, stated that "the primary objective in using the O&S cost model was to get the contractor to consider support costs during the design phase [14]." A similar statement was made by Mr. Robert Thomas, Fairchild's leading O&S model expert. He stated that the O&S cost model was to be used to increase the reliability and maintainability within design to cost constraints (29). These statements firmly establish that the contractors understood that the O&S cost model was to be used to assess support costs of the A-X aircraft in an attempt to minimize them.

Objective in Source Selection

The next objective of O&S cost model application to be addressed here will be that of using the O&S cost model to determine which of the competing weapon systems exhibited the least O&S costs over its ten year life cycle. A supplement to Project ABLE confirms this intent:

> Project Able makes it possible to include within the overall source selection process a meaningful approximation of the total life cycle cost of the systems being proposed by each bidder [18:vi].

Further investigation into this area verifies that the contractors were informed of this aspect of O&S model utilization. The "Strawman" model that was used to validate the O&S model states that:

> The contractors have been advised that it is the intention of the Air Force to use this model, or some similar model, to assess the supportability of the proposed hardware, and further, that the relative supportability will be one of the criteria on which the award of the production contract will be based [5:2].

A copy of the "Strawman" model was given to each competing contractor in June, 1970 (9:8).

Here again, this objective has been established by the designers of Project ABLE and transmitted to the contractors through documents of correspondence (in this case, the

"Strawman" model). Contractor understanding of this objective has been verified by documents prepared by the contractors: A Northrop publication states that one of the purposes of the O&S cost estimate was to "identify the potential operations and support cost of the A-9 [21:1]." Another publication obtained from the Fairchild-Republic Company states that "the [O&S] cost model provided a standardized and precise tool for application to the A-X source selection preliminary plan dated January, 1972 [9:3]." Thus, the objective can be briefly stated as follows: The results obtained by each contractor in using the O&S cost model would serve as a source selection criterion.

<u>Objective in Evaluating ECPs</u>

Investigation revealed that a further objective in the application of the O&S cost model to the A-X/A-10 acquisition was to be able to evaluate the impact of engineering change proposals (ECPs) on operation and support costs. Colonel J. E. Hildebrand, in a cover letter attached to the RFP, wrote: "The contractor's best efforts are required to identify the preferred designs of the A-X configuration items . . . [and] reduce the number and costs of ECPs [15]." Additionally, the Statement of Work clearly states that "the model will be used to determine the logistics effects of proposed configuration changes [3:5.3.12.2]." Additional documentation of this objective can be found in the Configuration Management section of the RFP:

> The Government evaluation of each ECP will include a quantification of the impact of the proposed change on all TLEs . . . . The contractor shall not implement an ECP until such action has been approved by the Government as outlined in MIL STD 480 . . . the change order approving those ECPs adopted will reflect the change (if any) in the contractual targets for all TLEs [2:40].

Research of contractor publications has verified that the contractors were well aware of this objective. Documents prepared by both contractors referred to the use of the O&S cost model to evaluate ECPs (9; 21).

<u>Objective in Award Fee Determination</u>

The final objective of O&S cost application to the A-X program deals with the awarding of an incentive fee. Project ABLE (16) stipulates that TLEs can be compared to MLEs collected during a validation period to determine the magnitude of an award or penalty to assess the winning bidder (16:7). This idea was presented to the contractors in the RFP, which stated: "The award fee arrangement shall be a function of the difference between TLE and the value of the corresponding MLE [3]." Documents provided by the competing contractors (9; 21) confirmed that they realized the O&S cost model would be used for this purpose. The Production Phase Proposal published by Northrop Corporation alluded to this objective in its introduction:

[A] purpose of this O&S cost estimate is to . . . establish support cost objectives that USAF can use to measure the success of the contractor in designing for minimum support requirements [21:1].

A similar article prepared by Fairchild-Republic Company discusses the use of the O&S cost model in granting an incentive fee (9).

Summary

Based upon the research findings cited above, the objectives of the application of the O&S cost model can be summarized as follows:

1. To instill in the contractors the incentive to consider logistics effects (O&S costs) in their designs of the A-X aircraft.

2. To serve as a criterion in source selection.

3. To aid in the evaluation of ECPs with respect to O&S costs.

4. To serve as a criterion in the granting of an award fee.

The information provided above has verified that these objectives were submitted to the contractors through the RFP, SOW, or other documents provided by the Air Force. Further, research has verified that the contractors received and understood these objectives. Subsequent portions of this thesis will assess the methods used to accomplish these objectives to determine whether or not they were met.

Chapter 4

AVAILABILITY OF DATA FROM DO56

Introduction

This chapter examines the data made available to Northrop and Fairchild-Republic to compute their Targeted Logistics Effects through the use of the DO56 Product Performance Collection System. This system, a product of AFM 66-1, is the central topic of this analysis. The reader will be introduced to the maintenance data philosophy expressed in Project ABLE and subsequent O&S cost model directives. Following this is an overview of the Air Force's exercising of the model utilizing F-4E maintenance data from DO56. The history of the Air Force's test use of the O&S cost model will then be compared to its use by the two prototype contractors—Northrop and Fairchild-Republic.

Maintenance Data Philosophy

Project ABLE (16), developed in late Spring and early Summer of 1969, is the foundation document of the O&S cost model (27). Irving Katz (16; 17; 18; 19) describes the model thusly:

> The model is driven by the characteristics of LRUs [Line Replaceable Units]. These characteristics

include RTS [Repairable This Station], NRTS [Not Repairable This Station], COND [Condemnation] rates, unit prices, repair costs . . . base and depot, and MTBF [Mean Time Between Failure] [16:B-7].

The TLEs driven by LRUs are TLE_1, initial and replenishment spares; TLE_2, off-equipment maintenance—excluding engines; and TLE_3, on-equipment maintenance (7; 9; 16). The contributions of TLEs 1-3 to the total predicted O&S costs cannot be overstated. Seventy-one percent of Fairchild's total TLE was accounted for by these three equations (9:13). Further, sixty-eight percent of the total MLE computed by the United States Air Force was found in these maintenance-related elements (9:23). Fuel costs, which contributed seventeen percent to the total MLE, were accounted for as prescribed in AFR 173-9, *Aircraft Fuel Consumption Data Collection*, and are not addressed in this study. What, then, is on-equipment and off-equipment maintenance?

> On-equipment maintenance [as defined in AFM 66-1, 11 Mar 68] . . . includes servicing, preventive maintenance (including preflights, postflights, and look phase[s] of scheduled organizational maintenance), time change removals and unscheduled removals [18:44].

Off-equipment cost figures are developed around the "average value of labor" where "[the] average cost to repair includes the average value of labor—salary, fringe benefits, overhead, and lost time—utilized in the repair process [18:44]." The RFP (2; 3) instructs the contractors to apply these labor cost figures to "the repair of [all] LRUs removed from the force over the 10 year life cycle [of the air vehicle] [2]."

In the Request for Proposal (RFP) transmitted to Northrop and Fairchild-Republic, the United States Air Force's philosophy on TLE computation was related as follows: "MTBR [Mean Time Between Removals] may be best supported by a comparison of the [proposed] hardware to hardware currently operational [in Air Force systems] [3]." Data elements provided by AFM 66-1/DO56 will include: (1) unit prices of LRUs, (2) depot costs, and (3) costs of maintenance consumables (2). Further, "AFM 66-1 data will be used [during] the test/validation period [2]." A study completed by the United States Air Force Academy (7) further embraces the use of AFM 66-1 maintenance data: "Necessary data for the [O&S] model comes from AFLC 66-1 data compiled . . . as part of routine Air Force KO51[2] computer runs [7:2-3]."

Air Force Exercise of Model

On 4 November 1970, Lt General Gideon, the AFLC Vice Commander, charged his Operations Analysis Office with exercising the Project ABLE model with "the necessary and appropriate data from within existing Air Force data systems [5:1]." In Technical Memorandum Number 14, published by the Operations Analysis Office, Headquarters, Air Force Logistics Command, the data base was defined as follows: "The bulk

[2]KO51 provides maintenance data inputs to DO56.

of the data used for the exercise was AFM 66-1 data as processed by the DO56 data [collection] system [5:1]." MLEs 1-3 were computed from AFM 66-1 data gathered during the simulated test period (5:5). Captain Raymond Cavender (5; 6), in his report *Application of the A-X 10-Year Operating and Support Cost Model to the F-4E*, provides the following insights to the problems encountered in computing on-equipment and off-equipment cost figures:

> In the first batch of data we obtained from the DO56 system, information had been collected by Work Unit Codes (WUCs). . . it was our intention to consider the WUCs as the identifiers of the line items in our computation. This approach soon got us into a great deal of trouble, resulting mainly from the fact [that] there were usually several Federal Stock Numbers (FSNs) reported against a single WUC . . . . As we got deeper into this problem, we realized that we could not use WUCs as identifiers of separate line items. The only way to extricate ourselves from the problem was to retrace our steps and gather data by FSN [5:6].

Work unit coded data was retained for use in the computations of on-equipment cost figures as these man-hours are collected by WUC, not FSN (5). Unfortunately, the off-equipment calculations were further hampered by the absence of depot level repair data in DO56. Captain Cavender continues:

> We lost track of an item once it went to the depot for repair . . . . As a result of this situation, we didn't have the data on [the] cost to repair individual failed items at [the] depot . . . . [To estimate costs] we fell back on the exchange rates from the Depot Maintenance Industrial Fund (DMIF)[3] . . . . [If] the

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[3]These exchange rates are computed by stock class and not by line item.

exchange rate was not computed, a world-wide average of 20% was used [5:10].

Despite these problems, the study (5) concluded that:

> This undertaking has indicated that the A-X Operating and Support Cost model can be meaningfully exercised using data generally available within current Air Force data systems [5:9].

Contractor Use of O&S Cost Model

The remaining portion of this chapter will address the guidance provided by the United States Air Force to Northrop and Fairchild-Republic concerning TLE computations and contractor experience in O&S model application.

The RFP transmitted to the prototype contractors provided the following guidance for LRU selection:

> A comparative analysis to hardware currently in military or commercial use will be considered suitable . . . detailed information will be input [to the Air Force] to the extent deemed feasible, and practical, to support the [repair] man-hour values claimed [2].

The primary United States Air Force provided data source was presented thusly: "The competing contractors on the A-X program [will] have access to large amounts of [maintenance] data, primarily through the [AFM] 66-1 data system . . . [6:5]." Air Force directives further stated labor rate estimates included in TLE_2 and TLE_3 were to include salary, fringe benefits, overhead, lost time, and consumable material for E-3, E-5, and E-7 skill levels (3). LRU maintenance was to be:

> . . . tracked through their repair or condemnation cycle through local [and/or] specialized repair

activities. The data . . . will be indexed by Manufacturer's Part Number and [federal] stock number [2].

The necessity for the contractors to have complete data with which to make their TLE computations was expressed by the Joint AFSC/AFLC Commanders' Working Group on Life Cycle Costing (35):

> The A-X/A-10 O and S cost model . . . require[s] input parameters which describe support requirements such as MTBR, base and depot repair costs and condemnation rates . . . the ability of the contractor[s] to acquire complete and valid data in a timely manner must be assessed at the time the model is definitized and its use specified [5:5,10].

The *relative* value of comprehensive maintenance data was expressed by Northrop Corporation in their "A-9 Operational and Support (O&S) Cost Summary":

> Maintenance analysis of USAF tactical aircraft and . . . [their] maintenance significant components show 15% of the maintenance components accounted for 80% of the air vehicle maintenance [21:8].

Mr. Robert Thomas (29; 30) further echoes this point in his "Data Requirements for O&S Cost Analysis—An Industry Point of View":

> Unless valid data is available and utilized, it is unlikely [that] there will be any resemblance between actual operating and support costs of a weapons system and that predicted. Thus time, effort, and money wasted [30].

When the contractors began to exercise the model, computing TLE_2 and TLE_3 became an unmanageable problem. A Fairchild publication states:

> Considerable confusion has existed on chargeable and non-chargeable maintenance hours for the prediction . . . of on-equipment and off-equipment maintenance . . . .

> Depot maintenance data was probably the biggest problem area encountered in obtaining data for the A-10 cost model exercise. Various channels were exercised in our efforts to obtain depot data . . . and the results received were very disheartening [30:v-6].

Mr. Herbert F. Harris, head of Northrop Corporation's Cost Analysis Branch during the A-X competition, supported Fairchild's position:

> Depot data—66-1—was hard to get because it was considered proprietary information. The 66-1 system seems difficult to manage as its reliability as a data base is questionable. Field data needs to be more reliable and controlled [14].

Fairchild, when requesting relief from this dilemma, stated:

> The problem with utilizing the 66-1 Maintenance Data Collection System is the incompatability between the maintenance [man-hour] data collected and the chargeable maintenance man-hours predicted by the contractor [40].

The United States Air Force's view of this problem was expressed by the Joint AFSC/AFLC Commander's Working Group on Life Cycle Costing:

> The lack of preparation of a data retrieval system to support the A-X O&S cost model input requirements placed an unacceptable burden upon the Deputy Program Manager for Logistics and [the] contractor logistics analysts when the data had to be retrieved on existing systems [AFM 66-1/DO56] for use in estimating A-X/A-10 model input values . . . . [The] unfamiliarity with various weapon systems, the maintenance data collection system, and the various coding techniques used by the Air Force caused a large expenditure of contractor resources [35:11].

The final problem in data completeness and usability arose when the United States Air Force evaluated the prototype contractor's TLE proposals.

> Since there was a limited time for proposal evaluation, the AFLC data bank could not be used for several reasons. [The contractors] gave Aeronautical Equipment Reference Numbers (AERNO) for some LRUs and Federal Stock Numbers (FSN) for others, the AFLC data bank is keyed primarily on Work Unit Codes (WUCs). The procedure to go from AERNO or FSN to WUC is not simple, and often the conversion was impossible because no acceptable cross-references were available in AFLC [35:11-12].

Summary

This chapter has introduced the reader to the D056 Maintenance Data Collection System and its contribution to the first three TLE formulae. A strong parallel exists among those maintenance data problems encountered in the first exercise of the model with F-4E D056 data, the contractors' TLE costing estimates, and the proposal evaluation board's attempts to judge each contractor's TLE. The lack of resolution of maintenance man-hour data problems, combined with no method of cross-referencing AERNO, FSN, and/or WUC data leads to the conclusion that the model cannot be exercised by data obtained from the D056 Maintenance Data Collection System, as used in the A-X/A-10 O&S cost model. Appendix D provides an overview of the AFM 66-1 Maintenance Data Collection System and its outputs. Alternatives will be discussed in the final chapter of this thesis.

Chapter 5

VALIDITY OF COMPARISONS BETWEEN CONTRACTOR TLEs

Introduction

Target Logistics Effects served as key variables in the application of the O&S cost model by allowing each contractor to project his success in reducing costs associated with reliability and maintainability. TLEs were used initially as part of the source selection process and later for the structuring of an incentive contract (19:8). This segment of the research will examine the techniques used by Fairchild-Republic Company and Northrop Corporation to calculate TLEs. The purpose here is to determine if the data and methods used to make these calculations were consistent between the contractors. Criteria established in the Methodology for this evaluation will be restated here:

1. The same data base must have been used by Northrop and Fairchild for TLE computations (historical data was to have been provided by the Air Force).

2. The same criteria must have been used by both contractors in the selection of LRUs.

The data provided by the Air Force and the techniques used for LRU selection will be analyzed in order to determine if a valid comparison can be made in accordance with Figure 2, page 16.

Data Base

To test the first criterion, contractor representatives were asked what data was provided them by the Air Force to exercise TLE computations. These computations were made from historical data collected on weapons systems currently in the USAF inventory (14; 29). According to Northrop's A-9 Production Phase Proposal, "USAF maintenance data for the F-4E, A-7D, F-105, F-5, F-100, A-37, and F-104 were used to relate A-9 maintenance requirements with currently operational hardware [21:4]." Fairchild also received maintenance data on inventory aircraft (30:5). Much of this data was provided to both contractors through the Maintenance Data Collection System specified in AFM 66-1 (24). An analysis of this data is provided in Chapter 4 of this thesis.

The information presented above supports the fact that both contractors were furnished with maintenance information from aircraft currently in the USAF inventory and that both contractors were provided equal access to the AFM 66-1 Maintenance Data Collection System.

LRU Selection

Questions were also addressed to the contractors' representatives regarding the process used in selecting LRUs to be assessed by the model. Documents were provided which explained the methods used to make these selections. The process used by Northrop in LRU selection is explained in the Production Phase Proposal:

> Maintenance analysis of USAF tactical aircraft and identification of maintenance significant components shows that 15 percent of the maintenance components account for 80 percent of air vehicle maintenance. This assessment of A-9 maintenance significant components was used to establish A-9 maintenance significant line replaceable units. The A-9 O&S LRUs include the hi-value hardware and those maintenance significant LRUs for which more than three removals are expected during the aircraft's design life. An initial list comprised of approximately 250 components has been compiled for particular emphasis [21:2,8-9].

This statement supports the fact that Northrop Corporation selected LRUs based upon items that were historically high-dollar maintenance items.

A study prepared by Fairchild-Republic Company describes their process used for LRU selection as follows:

> Forms were prepared, current and historical maintenance data was ordered, extracted and assembled and the maintenance prediction values for the parameters peculiar to this requirement were prepared by the system maintenance/maintainability engineer[s] . . . . The extensive military aircraft experience of the group enabled them to quickly identify over 500 LRUs and to select the most comparable in-service item for comparison [9:6].

Although no mention is made here of high O&S cost items, an interview with Fairchild-Republic's O&S cost expert indicated that this factor was considered in LRU selection (29).

It would appear that both companies based LRU selection on the criterion of high O&S cost. The disparity in the number of LRUs selected by each company, however, led to further research in this area. It was determined that problems were encountered by both contractors in the selection of LRUs. One such problem was the definition of the term LRU. This is expounded on in a paper written by Robert Thomas of Fairchild-Republic Company. He states:

> The definition of an LRU . . . caused concern in the designation of LRUs to be used in the cost model . . . . Almost any part of an aircraft can be removed and replaced on the flight line . . . . Also, in an effort to simplify the O&S costing exercise, calculations were made on what was considered as significant and cost sensitive LRUs. However, by definition in the cost model, even minor, low cost insensitive items are LRUs [30:5].

These views were also expressed by Northrop personnel (13; 14). There was no guidance given by the Air Force concerning what LRUs should be examined and what should be deemed as high cost drivers (14). A study prepared by the Joint AFSC/AFLC Commanders' Working Group on Life Cycle Costing verifies the lack of Air Force participation in the LRU selection process:

> Prior to the source selection period those LRUs comprising either the A-9 or the A-10 weapons systems were unknown until the proposals were received by the evaluation board [35:11].

Results of the research cited above support the fact that LRU selection was done by each contractor separately, with minimum coordination with the Air Force. While attempts were made by both contractors to select high O&S cost drivers as LRUs, no agreement was reached on the definition of the term "high cost" or, for that matter, the definition of "LRU" (14; 29).

Summary and Conclusions

To determine if a valid comparison between contractor TLEs can be made, two criteria have been tested here. The first addresses the data base used by the contractors. Information cited above supports the fact that both contractors were provided with historical maintenance data from operational USAF aircraft and both contractors were given equal access to the USAF Maintenance Data Collection System. This is sufficient to support achievement of criterion number 1.

Criterion number 2 deals with the criteria used by each contractor to select LRUs. It has been determined that there was a lack of coordination between contractors coupled with the absence of firm definitions by the USAF of the terms 'LRU' and 'high cost'. Contractor determination of LRUs was done independently using different criteria. Therefore, criterion number 2 is violated. Thus, any comparison between contractor TLEs regarding O&S cost would not be valid. This is illustrated in Figure 4.

IF

$DATA_F$ $\approx$ $DATA_N$

AND

LRU $DETERMINATION_F$ $\not\approx$ LRU $DETERMINATION_N$

THEN:

TLE COMPARISON → INVALID

Where:

F = Fairchild
N = Northrop
$\approx$ = Consistent
DATA = Data Base
LRU DETERMINATION = Criteria used to identify LRUs

Figure 4

Actual Comparisons Between Contractor TLEs

Chapter 6

VALIDITY OF COMPARISONS BETWEEN TLEs AND MLEs

Introduction

As stated in Chapter 3, one of the objectives of O&S cost model applications in the A-X/A-10 acquisition was to use the model as a device for determining the magnitude of an award fee. Irving Katz refers to this application in Project ABLE where he states:

> The difference between MLE and the TLE of the winning bidder is treated by a predetermined arrangement through which the government and the contractor share in the extra benefits or extra penalties [17:7].

In order to compare TLEs and MLEs, "there must be complete compatibility between them in terms of scope, timing and ground rules [7:3]." The purpose of this chapter is to determine if such compatibility existed between Fairchild's TLE projections and the Air Force's MLE projections. The criteria by which this assessment has been made are listed in the Methodology and will be restated now:

1. The same components (LRUs) must have been evaluated by the contractor and the Air Force.

2. Data for the computation of TLEs and MLEs had to be sufficient to make a valid projection of O&S costs for the LRUs being evaluated.

3. The methods used to develop the projection from TLEs had to be the same methods used to develop the 10 year projection from MLEs.

The first of these three criteria can be associated with scope, and the last two with timing and ground rules.

Components Evaluated

The first criterion was the simplest to test. The intention to evaluate the same LRUs when computing TLEs and MLEs was suggested in the "Strawman" model:

> The winner of the contract is contractually bound to achieve in the test period a composite of test values such that when they are put through the same model, a measured logistics effect as least as good i.e. (as low) as the TLE will result [5:4].

Further documentation provided support for the fact that the LRUs evaluated were to be the same for TLEs and MLEs. The RFP states that analogues for TLEs shall be denoted MLEs and the same LRUs are specified (2). A United States Air Force Academy study on the O&S cost model application states that "MLEs are exactly analogous to TLEs, except that MLEs use operational data instead of estimates based on historical experience as in TLEs [7:4]." Interviews with contractor representatives and SPO representatives confirmed that the list of LRUs selected by the contractor was submitted to the SPO and that these LRUs were evaluated for MLE computations (24; 29). Based on the foregoing information, TLEs and MLEs were compatible in terms of scope.

Sufficiency of Data

Data availability via the DO56 has previously been addressed in Chapter 4. In this section, we will examine sufficiency of the data used in actual O&S cost computations for TLEs and MLEs. The ability of the contractor to obtain sufficient data, despite the problems encountered in using DO56 data, will be examined now.

Contractor data. Several specific problem areas have been pointed out by the Fairchild-Republic Company. In a report published by that company, the following statement appears:

> Data for WUC 01 Ground Handling, Servicing and Related Tasks, is not available to contractors for predictive analysis or contractor verification. Since WUC 01 MLE for the A-10 was 25% of the total on-equipment maintenance [MLE_3] which in turn was 53.5% of the total MLE, it can readily be seen that this is a very significant maintenance cost [9:12].

Similar problems were incurred with Depot Repair man-hour data. This data was not available to the contractor because it is competition sensitive (14).. The 66-1 MDC system does not report this data (9:12).

Another article written by Mr. Robert Thomas of Fairchild states that no definition of chargeable maintenance man-hours was presented to the contractor. The problem was whether to consider only productive direct maintenance costs or all inclusive maintenance costs reported in the 66-1 Maintenance Data Collection System (30:5, 7). The problem of defining exactly what costs to include and what costs to exclude for labor mentioned above, and other costs, was not resolved. Fairchild-Republic summarizes this problem by stating that:

> More definition is required here to specify what is to be included and excluded, for example, Weapons Loading, and more information is required as to availability of sources of comparative data for predictive analysis in this and other support general categories [9:12].

If Fairchild included only direct labor costs in its TLE calculations and the Air Force included both direct and indirect labor costs, the ability to make a valid comparison between TLEs and MLEs would be significantly impaired. Lack of clear definitions for certain data inputs required to exercise the model may have led the contractor to include some costs that were excluded by the Air Force and vice versa.

USAF data. Having examined the data input problems related to contractor TLE computations, an analogous study will now be reviewed regarding Air Force MLE computations. Computations of MLEs 1-4 were computer augmented with K051 data[4] and fed into this program automatically (7:4). This investigation dealt only with calculations of MLEs 1-4. The MLE projections used by the Award Fee Determination Board were derived from 5,287 hours of flying time (9:10). According to one United States Air Force Academy (USAFA) study:

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[4]A subsystem of D056.

> The 5000 hour timeframe is inadequate for several reasons. By the time 5000 hours of flying time has been accumulated on the airframe, many of the LRU prices are still not available. The data itself is incomplete at this point because it lacks information on removal rates of numerous LRUs. Some LRUs are just not removed before 5000 hours [7:9].

Further investigation was conducted in this area to determine the methods of arriving at and the accuracy of unit prices. This investigation revealed that approximately sixty-five percent of the unit prices of the LRUs had to be estimated at the 5,287 hour point. These estimates were, for the most part, obtained from conferring with engineering personnel who were familiar with prices of comparable systems in the USAF inventory (11). To determine the accuracy of these estimates, twenty LRUs were selected at random and actual prices for these LRUs were obtained from the item managers at their respective ALCs. Of these twenty items, thirteen had been replaced by new FSNs and prices, which did not appear in any of the computer products. Of the seven remaining items, two were correct and the other five were overstated. Results show that the estimated prices were overestimated by an average of forty percent. This clearly indicates that the 5000 hour point, because of insufficient data on actual unit prices, was inadequate for accurate MLE computations.

An analysis was conducted to determine if there was a significant difference in LRU removal rates between the 5000 hour point and the 25,000 hour point. In some instances, removal rates could not be tracked on a cumulative basis at any point in time. A recent study conducted by the USAFA (32), in October 1977, addressed this problem. This study stated that test removals were not being properly aggregated in the computer runs. Mean Times Between Removal (MTBR) were being computed using aggregated flying hours and unaggregated test removals (TR) (32). The SPO initiated action for changes to be made in the program in an attempt to correct this prob (24; 31). It was subsequently determined that data was not aggregated in the program because the AFM 66-1 system does not retain the data for a long enough period (36; 37). "Even if the program had the capability to aggregate test removals, it would not have had the data to do so [11]." Since MTBRs and aggregated test removals are necessary inputs for the O&S cost model, inaccuracies in these figures would result in inaccuracies in the final MLE figures, rendering any comparison between TLEs and MLEs questionable at best.

Methods of Application

The methods used to calculate TLEs and MLEs were examined to determine if any aspects of model application adversely affected the comparison made between them.

One important aspect considered was the time period over which the TLEs and MLEs were calculated. Katz stated the importance of using the same time period for TLE and

MLE calculations in the ABLE study (16:3). Using the same time period for evaluation of TLEs and MLEs is important because of the difference in O&S costs that are experienced throughout the life cycle of a weapons system (7:5). This difference is demonstrated by the "bathtub" curve in Figure 5 which is widely accepted as typical of O&S costs for most weapons systems (22:178). The Incentive Award Provisions of the Statement of Work (SOW) specify that the analysis of the differences between the TLEs and MLEs shall be for the same time period (3).

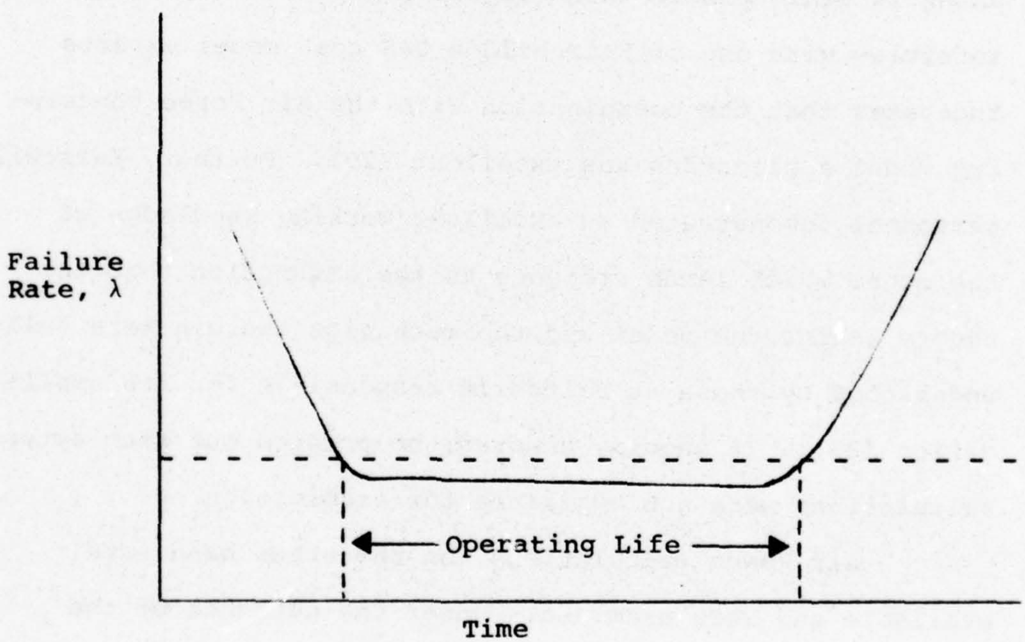

Figure 5

Failure Rate Versus Time [22:178]

According to a Fairchild report, the Air Force instituted a change in the measurement period after the contract was awarded and "final agreements were reached relative to the change in TLE value to accord with the change in the measurement period [9:10]." Based upon this information, TLEs and MLEs were compatible in terms of timing.

Further investigation was conducted in other areas of model application. Documents verify that the contractor was provided with specific instructions regarding the application of the O&S cost model (2; 3; 9; 10; 29). An entire annex is dedicated to this subject in the RFP (3). An interview with one of Fairchild's O&S cost model experts indicates that the coordination with the Air Force concerning model application was excellent (29). Further, Fairchild personnel demonstrated an excellent working knowledge of the model which lends credence to the assumption that the theory behind the model and the mechanics therein were fully understood by those at Fairchild responsible for its application (29). It should, however, be pointed out that actual calculations were not available for examination.

Air Force calculations, on the other hand, are available and were examined. Under the guidance of the SPO, the formulae were applied using the 5,287 hour data and it was determined that these formulae were properly exercised by the computer (29). Problems were discovered in the computation of MLE_1. The 5,287 hour O&S cost model computer product for MLEs 1-4 shows the total of MLE_1 to be approximately 159 million dollars, while the final report used by the Evaluation Board shows this figure to be 78.4 million dollars. In discussing this discrepancy with the SPO, it was determined that the computer program was overstating MLE_1 due to problems in the 1300[5] WUC area. In this area, several WUCs exhibited extremely high unit prices. Additionally, test removals were reported for items such as wheels and brake assemblies when only tire removals should have been reported. Manual alterations were administered in order to correct these discrepancies (24). This accounts for the difference in the computed value of MLE_1 and the reported value. Another manual change was the addition of support general cost data to the computed value of MLEs (1). It was not possible to track the accuracy of these manual changes. Therefore, no firm conclusions can be made concerning the compatibility of Air Force and contractor application techniques.

Summary and Conclusions

As stated earlier in this chapter, a valid comparison between TLEs and MLEs requires complete compatibility in terms of scope, timing, and ground rules. Thus, only if the same LRUs were evaluated by both the Air Force and the

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[5]Wheels, tires and brakes.

contractor, *and* sufficient data was available for 10-year O&S cost projections, *and* the methods used to develop TLEs and MLEs were the same, could a valid comparison be made.

The findings discussed in this chapter reveal that although the same LRUs were evaluated by both Fairchild and the Air Force, data deficiencies negate the validity of comparisons between TLEs developed by Fairchild and MLEs computed by the Air Force. Additionally, the problems encountered by the Air Force in applying the model cast serious doubt upon the ability to make valid TLE/MLE comparisons. This is illustrated in Figure 6.

IF

$LRU_F \approx LRU_{AF}$

AND

$DATA_F \not\approx DATA_{AF}$

AND

$METHOD_F \stackrel{?}{\approx} METHOD_{AF}$

THEN:

TLE/MLE COMPARISON → INVALID

Where:

F = Fairchild
AF = Air Force
$\approx$ = Consistent
DATA = Data used for O&S cost projections
LRU = Line Replaceable Units
METHOD = Method of Application

Figure 6

Actual Comparison of Contractor TLEs
and Air Force MLEs

Chapter 7

ACCOMPLISHMENT OF AIR FORCE OBJECTIVES

Introduction

Chapters 4—6 of this thesis analyzed the basic tools required to apply the O&S cost model: data, TLE computations, and MLE computations. The conclusions reached in those chapters will now be applied to determine if the Air Force objectives established in Chapter 3 were accomplished by O&S cost model application to the A-X/A-10 acquisition. Additional information, where needed, will be presented in order to make this determination. Each objective will be evaluated separately and tested against the criteria established in the Methodology and restated below:

1. The model must have been employed toward accomplishing this objective.

2. The data and techniques used in applying the O&S cost model must have resulted in valid or accurate information for use in accomplishing this objective.

The Overall Objective

As stated in Chapter 3, the overall objective of O&S cost model application was to instill in the contractors the incentive to consider logistics effects (O&S costs) in their designs of the A-X aircraft. By stating their intent to use this model in the RFP (2; 3) and subsequently carrying out this intent through actual use of the model (1), the Air Force fulfilled the requirement established in criterion number 1.

Testing the second criterion was difficult regarding this objective because of its general nature. The motivation of the contractors to emphasize O&S cost considerations was not dependent upon the *results* of O&S cost model application, but rather a product of the knowledge that the Air Force was considering ownership costs a primary factor in A-X acquisition (13; 14; 29).

Northrop personnel confirmed that their company *did* give more consideration to O&S costs because of the application of the O&S cost model. One Northrop executive stated that O&S cost model application had a distinct impact on support costs of the airplane (13). Another stated that although O&S costs were always considered in aircraft designs, from the standpoint of compromising weight increases in the aircraft for increased R&M, the O&S cost model made a difference. He further stated that the cost plus incentive contract combined with O&S cost model application motivated the contractor toward better design (14). A Fairchild representative expressed similar views concerning the influence of the O&S cost model on aircraft design. He stated, "Much of the aircraft design was governed by design-to-cost constraints and by support cost considerations in the O&S cost model [29]."

If greater consideration *was* given to O&S costs in the design of the A-10 aircraft, it would logically follow that the aircraft has proven itself in terms of reliability and maintainability. Since the beginning of its operational flying, the A-10 has exhibited a high rate of operational readiness (OR). In fact, according to the A-10 SPO director, the "reliability of the system is almost twice that projected for maturity [4]."

The evidence provided above is sufficient to support the fact that the contractors were motivated by O&S cost model application to consider support costs in the design of the A-X aircraft. Further, this consideration has resulted in a weapon system that has demonstrated a higher OR rate than projected. These facts lead to the conclusion that the overall objective of O&S cost model application was accomplished.

Use of the Model in Source Selection

The next objective to be evaluated is the use of the O&S cost model TLE computations as a criterion for source selection. The members who sat on the source selection board could not be contacted for interviews; therefore, the research team relied upon document research to determine if the O&S cost model was employed toward the selection of the winning contractor. A study conducted by the Joint AFSC/AFLC Commanders' Working Group on Life Cycle Costing states, "During the proposal evaluation period, the data necessary for a thorough Air Force validation of the contractors' bid target logistic effects were not available [35:11]." Therefore, any comparison made by the Source Selection Board between contractor TLEs would have been of questionable value. Additionally, it has already been established in Chapter 5 that TLE computations cannot be meaningfully compared because of the different criteria used by each contractor in selecting LRUs to be evaluated.

Finally, investigation of TLE values has revealed that the TLE total submitted by Northrop Corporation ($821.3 million) was approximately $19 million less than that submitted by Fairchild ($840.3 million) (9; 21). Therefore, it is clear that the Source Selection Board did not consider the TLEs computed by the contractors as a significant basis for source selection. Hence, the Air Force objective to use the application of the O&S cost model as a criterion for source selection was not accomplished.

Use of the Model in ECP Evaluation

The intent to use the O&S cost model to evaluate ECPs has been firmly established in Chapter 3. The methods by which this was to be done and the success of this application of the model will be addressed now.

The detailed procedures for preparing and presenting O&S cost data for ECP changes are spelled out in an Engineering Release (ER) published by Fairchild-Republic Company in April, 1977. The procedures are summarized in a later document published by Fairchild:

> To permit this evaluation of Logistics effects, the contractor's analysis of each Class I ECP shall include a comparison of the differences in TLE values as computed for the baseline weapon system configuration versus that resulting under the proposed ECP . . . . Upon notification of an approved ECP, the O&S costing activity posts the delta values for each of the thirteen model elements on the matrix log previously prepared to show the baseline changes [9:7-8].

That the model was actually used in this manner is confirmed by the following statement:

> To date, approximately 65 approved changes have been added to the matrix, with a net increase of approximately four percent to the baseline total cost prediction [9:8].

Having established that the O&S cost model was used to evaluate the cost impacts of ECPs, the results provided by this evaluation will now be examined. The SPO was contacted to determine how successful the use of the O&S cost model was in this regard. This investigation revealed that the SPO had initiated action in March, 1978, to discontinue this particular application of the model in favor of another model provided in the "Logistics Support Cost Model User's Handbook" (33). This decision was the result of an in-depth study by SPO personnel of the effectiveness of using the O&S cost model in ECP evaluation (25). The conclusion of this study was that:

> The current [O&S] model is not a good tool to use for ECP purposes because:
> a. Some of the equations are not sufficiently explicit (e.g., Peculiar Support Equipment).
> b. The equations do not accurately reflect present Air Force operations (e.g., spare safety levels, equipment usage).
> c. Air Force supplied parameter values and constants are out of date and unrealistic when compared to current programmed flying hours, aircraft inventory and airframe life projections.
> d. Contractor provided parameter values and constants are also unrealistic [33:2].

The originator of this study further states:

> If this update to the O&S cost impacts on ECPs is not accomplished we will continue to receive a misleading, inaccurate, 1970 baselined assessment in future analyses [33:2].

Based on this information, the only logical conclusion regarding the use of the O&S model as a tool in evaluating ECPs is that the model is ineffective. Therefore, the objective of using the O&S cost model for this purpose was not accomplished.

Use of the Model in Incentive Award Determination

To determine the actual role of the O&S cost model in making an award fee determination, the A-10 SPO director, who served as a member of the Incentive Award Fee Board, was interviewed. He stated that the degree to which the O&S cost model was used is proprietary information. However, "a very large part of the incentive award fee was based on TLE/MLE comparisons [4]." This is sufficient to conclude that criterion number 1, regarding the use of the model toward this objective, was met.

Chapter 6 is an in-depth study of the validity of TLE/MLE comparisons. Due to extensive problems with data availability and model application in this area, it has been determined that a valid comparison between TLEs and MLEs cannot be made.

Another factor that warrants mention here is that a large part of the contractor's incentive to compute TLEs as accurately as possible was compromised by the method in which the model was employed in this area. Project ABLE stipulates that TLEs are to be computed *during the competitive phase* of the acquisition process to insure that they are not inflated (4:2-6). Research has revealed that Fairchild was instructed by the USAF to recompute its TLE figures on at least four occasions subsequent to contract award (March 1973). The results of these computations are presented in Table 3.

TABLE 3

FAIRCHILD-REPUBLIC TARGETED LOGISTICS EFFECTS

TLE	DATE	AMOUNT ($ MILLION)
Revised	25 Jun 73	819.5
Baseline	30 May 74	836.2
Baseline + ECP	1 Apr 76	832.8
Final	30 Apr 77	919.2

(9:19-23)

Each of these changes was a result of some government action regarding changes to the rules by which the MLEs would be computed (9:7,9). The fact that these revisions to TLEs were made subsequent to contract award negates the competitive incentive to keep these figures as low as possible. In fact, it is now to the contractor's advantage to make these estimates as high as possible in order to enhance the chances of a favorable comparison to MLEs computed by the government (4:2-6).

Although the O&S model was a major consideration in the award fee determination, the inability to make valid TLE/MLE comparisons because of the factors presented above and in Chapter 6 casts very serious doubt on the usefulness of the O&S cost model in this area. Therefore, it is concluded that the objective of using the O&S cost model to aid in the determination of an award fee was not accomplished.

Conclusions

The application of the O&S cost model to the acquisition of the A-10 did result in a better, more reliable weapon system through the accomplishment of the overall objective as stated earlier.

Due to problems encountered with obtaining data and model application deficiencies, it has been determined that none of the other Air Force objectives in O&S cost model application were accomplished. Unless steps are taken to correct these problems, the accomplishment of the overall objective by future users will be jeopardized. This was confirmed by one Fairchild representative who stated that any future emphasis on the use of this model by his company will require increased efforts by the Air Force to correct deficient areas (29). The last chapter of this thesis will present recommendations for correcting these deficiencies.

Chapter 8

CONCLUSION AND RECOMMENDATIONS

The O&S cost model *can* be a valuable tool for increasing the reliability and maintainability of new weapon systems. It has proven its worth in motivating contractors to consider cost of ownership in the design of new aircraft. It is clear that the first application of the model had problems. For improved future use, these problems must be analyzed and resolved. Analyses of the problem areas appear in Chapters 4 through 7. This chapter is dedicated to recommendations for resolving problems in the areas of data availability, TLE/TLE comparisons, TLE/MLE comparisons, and accomplishment of Air Force objectives. Additionally, conclusions are drawn concerning the future use of this O&S cost model. It is not intended that these recommendations be considered collectively exhaustive or mutually exclusive; the need for further research is examined in the final pages of this chapter.

Data Availability

As stated earlier (in Chapter 4), the A-X/A-10 O&S cost model cannot be exercised strictly on the basis of data obtained from the DO56 Product Performance Collection System. Problems encountered by the Air Force and contractors preventing achievement of this objective are summarized below.

1. Off-equipment TLE calculations were hampered by the absence of depot-level repair data in D056.

2. Work Unit Codes were not line item identifiers; more than one FSN was reported against a single WUC.

3. There was no acceptable cross-reference system to convert contractor Aeronautical Equipment Reference Number (AERNO) or Federal Stock Number (FSN) to Work Unit Code (WUC).

A suggested means of solving the first problem concerning the absence of depot-level data is provided in the "TLE/MLE Comparisons" section of this chapter. Resolution of problems two and three require action on the part of the Integrated Logistics Support (ILS) Branch of the concerned SPO. The ILS Branch must insure that each WUC has its own unique stock number. This will probably increase the number of work unit codes, but it will provide the identification of each unique LRU. LRUs that consist of stock numbered subassemblies are the largest contributors to the problems encountered in the "line-item-identifier" concept in the A-X/A-10 O&S cost model. An error listing that compares a previous month's stock number and WUC to the current month's stock number and WUC should be used to flag changes in these relationships. This would be more cost effective than screening the entire document. Of course, this technique would be effective only after the initial run is evaluated and corrected. Additionally, a list of cross-referenced AERNOs and FSNs should be solicited from the contractor and used to further cross-reference with Air Force WUCs. Another related problem was the lack of definition among line item identifiers and prices (see Chapter 7). The aforementioned technique would insure that each price would be specific for each line item. A clear distinction would then be made between assemblies and subassemblies.

TLE/TLE Comparisons

Chapter 5 cited problems concerning the selection of LRUs which led to the inability to make a valid comparison between contractor TLEs. The specific problems cited were:

1. The contractors failed to use the same criteria for LRU selection.

2. The Air Force failed to specifically define the terms "LRU" and "high cost".

The selection of LRUs is *the* most important step in TLE computations. The seemingly infinite list of LRUs that comprise an entire weapon system must be scrutinized by each contractor to determine which ones are significant enough to be considered high cost drivers. To add to this problem, the contractor does not want to include any LRUs that might be unique to his aircraft thereby driving his TLE figure higher than his competitor. The Auxiliary Power Unit (APU) on the A-9 is a good example of this. Northrop included an APU in its original design whereas Fairchild did not (14). O&S costs for the APU were included in Northrop's TLE computations and no comparable LRU was considered in Fairchild's TLE. The contractors were asked how LRU selection might be standardized. Northrop recommended that each contractor submit a list of LRUs to the Air Force and that the Air Force then discriminate between similar LRUs and peculiar LRUs. The similar LRUs could then be compared directly in terms of TLEs whereas the peculiar LRUs could be evaluated separately in terms of O&S costs and improved performance (14). Fairchild suggested that only the top fifty or 100 O&S cost drivers of each aircraft be evaluated via the O&S cost model (39). Both of these suggestions are feasible and both would standardize the LRU selection process, although Fairchild's suggestion may not provide the degree of O&S cost coverage that other alternatives would.

Research has revealed another possible solution to the problem of LRU selection which is recommended by this research team. Northrop's analysis of historical data of inventory aircraft revealed that 15 percent of all LRUs account for 80 percent of the total O&S costs (21:8). The Air Force should compile a list of these LRUs and submit a copy to each contractor. The contractor should then develop a list of LRUs for his aircraft which are comparable to those on the Air Force list. From the contractors' lists, the Air Force could then develop a final list of LRUs to be evaluated regarding O&S costs. In this way the Air Force could insure compatibility of TLEs for comparison without considering the total O&S costs for the entire weapon system. This would also solve the problem of defining the terms "LRU" and "high cost," for discrimination in these areas would now be in the hands of the Air Force.

If the preceding solution is not employed however, the problem of defining terms "LRU" and "high cost" will still exist. The definition of LRU provided to the contractors states:

> A component of a system that is designed for removal when it malfunctions and is replaced with a like unit by operating squadron personnel performing on-equipment maintenance on board the aircraft or on the flight line [30:2].

Fairchild pointed out that this could apply to just about any system on the aircraft (see Chapter 5, page 39). Fairchild solved this problem by adding the word "normally" to the definition (30:5). If both contractors had done this, the problem may have been solved. A better solution, however, would be for the Air Force to scrutinize the contractors' proposed LRUs and make the determination as to whether or not the items are, in fact, LRUs. The solution to the problem of defining "high cost" can be resolved by simply stipulating a dollar value in terms of cost to maintain or replace the item over the projected life cycle of the weapon system.

If these recommendations had been instituted in the initial application of the O&S cost model, the comparison between contractor TLEs would have been meaningful. Future implementation of these recommendations will enhance the probability that a valid comparison between TLEs can be made.

TLE/MLE Comparisons

Comparisons between Fairchild's TLEs and Air Force's MLEs were determined to be invalid in Chapter 6 due to the following problems:

1. Lack of sufficient data on the part of the contractor.

2. Lack of clear definition concerning what costs to include and what costs to exclude.

3. Lack of sufficient unit price data on the part of the Air Force.

4. Inability to track and aggregate test removals.

5. The need to make manual adjustments to the computer product for MLEs 1-4.

The lack of sufficient data for contract computation of TLEs lies mainly in the areas of on-equipment maintenance and depot repair man-hours. In instances where data is unavailable, it is recommended that the Air Force establish numerical constants to be used in the O&S cost model equations. For example, such constants may be supplied in the area of depot repair man-hours. While this solution would not insure accuracy of TLE/MLE computations, as long as the same numbers were used by the Air Force and the contractor, a valid relative comparison could be made. The number of items going to depot for repair would become the major variable in these calculations and would be the major reason for TLE and MLE differences. A less specific, but related, recommendation for solving this problem is presented by the contractor in a Fairchild publication:

> The recommendation here is that if depot repair costs must be included, more recognition should be given to data non-availability and prior determination specified relative to measurement methods and status [9:12].

Improved communication between the contractors and the USAF is important in solving the problem of providing sufficient data to the contractor. A management structure which will facilitate the implementation of the recommendations stated here is presented in a later portion of this chapter. Such a structure will also provide for more precise definition of costs to include and costs to exclude when computing TLEs.

The problem of unit price availability was largely a result of the short period allowed for validation (5,287 hours). A partial solution to this problem would, therefore, be to extend the validation period. It is recommended that future validation periods be set at no less than 10,000 hours of operational flying time. This will allow more time for pricing information to be gathered (7:6). A disadvantage of extending the validation period is that the contractor would have to wait a longer period for the award fee. General Brill recommended that, to solve this problem, the award fee might be granted in phases. For example, a certain percentage could be granted at the end of 5000 hours, a larger percentage at 7000 hours and so forth. The percentages of possible award fee could be increased as information became more reliable (4).

Another aspect of the unit price problem is that of updating prices. Here again, the management structure proposed in this chapter will provide communication channels to insure that price information required for the computation of MLEs 1-4 is kept current. The inability to aggregate test removals beyond the quarterly period is a problem which is also addressed in Chapter 6. It is recommended that, since data is not maintained for a long enough period to properly aggregate this information, all calculations be done on a quarterly basis. The summation of quarterly data for each MLE (MLEs 1-4) could then be accomplished for as many quarters as the validation period may require. This would necessitate minor changes in the current computer program which performs these calculations.

The final problem revealed by this investigation in the area of TLE/MLE comparisons is that of having to make manual changes in the computer program. Many of these changes were necessitated by problems with unit prices and WUCs not identifying the proper subassemblies (see Chapter 6).

Closer monitoring of maintenance reports is required in this area to preclude such problems. Closer monitoring will be possible with the implementation of the new management structure.

The final problem considered in the area of TLE/MLE comparisons is that of adjusting TLE values after contract award. As stated previously, this negates the contractor's incentive to keep his TLE values as low as possible. It is recommended that the TLE/MLE comparison should be made based upon original LRUs only. Any ECPs would not be considered in this comparison. Any LRUs that have been deleted due to ECPs could simply be removed from the contractor's original TLE and not considered by the Air Force in its MLE computation. There are two advantages to be gained here:

1. The award fee will be based on TLE values that were computed prior to contract award.

2. The contractor will not be penalized for recommending ECPs to improve aircraft performance.

Implementation of the recommendations presented in this section will enhance the ability of an Evaluation Board to make valid comparisons between TLEs and MLEs. The ability to implement these recommendations is largely dependent upon the development of a project management structure that will provide the means for such implementation.

Project Management of O&S Cost Model Application

The importance, complexity, and effort of O&S cost model application leads to the conclusion that it *is*, in and of, itself a project which should be separately managed within the SPO. To obtain accuracy in the calculations of TLEs and MLEs requires constant management and monitoring at all levels involved with the maintenance of the weapon system. An organizational structure for project management of O&S costing will be presented in this chapter. The advantages of project management cannot be overstated. The structure proposed here will increase the SPO's ability to monitor this aspect of the acquisition process. It will do this with a minimum increase in manpower and without requiring changes in the current data system. Further, the development of such a management structure will demonstrate to the contractors that the Air Force is seeking to improve its ability to administer life cycle costing techniques in the acquisition process, thereby increasing the contractors' motivation in this area. Channels of communication for handling various problem areas will be illustrated. This research team firmly believes that improved management techniques are the key to successful administration of the O&S cost model.

The main personnel involved with the application of the O&S cost model are:

1. Contractor O&S model personnel.

2. Integrated Logistics Support (ILS) Branch of the SPO.

3. Item Managers (IM) at ALCs.

4. Production Analysis Section, Deputy Commander for Maintenance (DCM).

5. ALC personnel involved with the computer augmented portion of the model.

It is recommended that a project management structure be established in accordance with Figure 7.

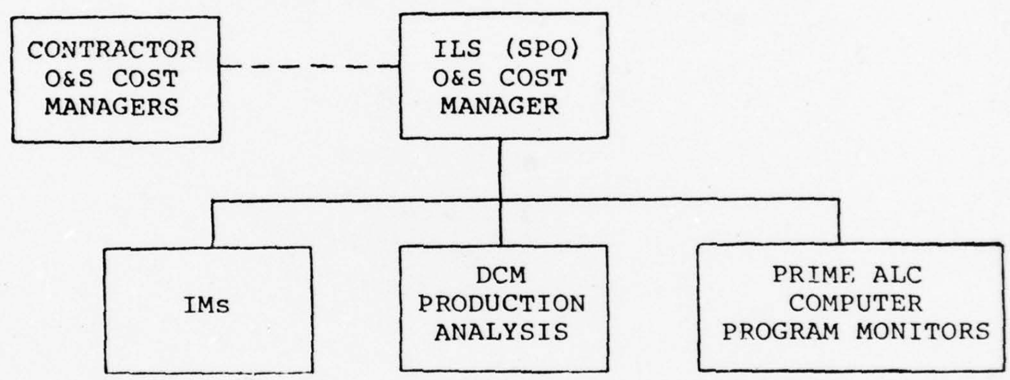

Figure 7

Project Management Structure

The SPO O&S Cost Manager will be the center of communication among all agencies and the only communication point with the contractors. The Item Managers will be required to report all price and LRU changes to the SPO O&S Cost Manager. He could, in turn, relay this information to the computer program monitors at the prime ALC for input changes. This channel of communication would insure that price and WUC information is kept current in the computer augmented portion of the O&S cost model.

Constant communication is required between the Production Analysis Section, Deputy Commander for Maintenance, and the SPO O&S Cost Manager to insure that WUC and man-hour information is being accurately reported. Screening of the maintenance reports received from the flight line should be mandatory in the case of new systems being evaluated by the O&S cost model. Presently, such screening is optional (36:3-1). If problems are detected by the SPO Manager, immediate action should be taken to correct them. An example of such a problem existed in the 1300 WUC category of the A-10. The 1300 WUC encompasses wheels, brakes, and tires. In the A-10 application of the model, tire changes were being misreported as removals of the entire assembly. This channel of communication will help to alleviate problems concerning WUC and FSN identification mentioned in the "Data Availability From D056" portion of this chapter.

With this management structure, the SPO O&S Manager can maintain constant communication with the prime ALC computer program monitors to insure that all problems with computer inputs and programming are resolved immediately.

Finally, the contractor will have a definite source to go to to resolve problems with obtaining data, i.e., the

O&S Cost Manager in the SPO. The Cost Manager can rely on his expertise or defer to one of the other sources available to him to obtain information for the contractors.

All personnel involved in this program management structure must be thoroughly briefed on the essential part that they will play in O&S cost model application. Adoption of this project management plan will facilitate the implementation of the other recommendations presented in this chapter.

Future Use of O&S Cost Model

It is necessary to assess whether or not the original Air Force objectives can be accomplished through implementation of these recommendations.

Overall objective. It has been established that the overall objective of model application was accomplished in its initial application. It has also been determined that the credibility of model validity has declined in the eyes of the contractors due to its deficiencies. It is logical to conclude that correcting these deficiencies is essential to the accomplishment of this objective in the future.

Objective in source selection. The objective of using the O&S model as a source selection criterion is a realistic one which can be accomplished by implementing the recommendations presented in this chapter. Standardization of LRU selection and improved data availability will insure accomplishment of this objective.

Objective in ECP evaluation. Use of the O&S cost model to evaluate ECPs has proven to be an unrealistic objective. The SPO's research presented in Chapter 7 affirms this conclusion. Therefore, it is recommended that the O&S cost model not be used toward this end. Other models are more appropriately designed for ECP cost impact studies.

Objective in award fee determination. The O&S cost model was not an effective tool in making an award fee determination in the A-10 case. It can, however, be used effectively toward this end if the recommendations submitted in this chapter are instituted. Better data management, improved contractor-SPO communication and procedural changes in Air Force computation techniques will lead to valid TLE/MLE comparisons. This, in turn, will result in the successful accomplishment of this objective.

Recommendations for Further Study

During the course of this research, several areas have been touched upon which were outside the scope of this study, but which warrant closer examination. Support should be provided for further research in the following areas:

1. A methodology for gathering the data required for O&S cost model application should be developed. Instead of providing contractors with access to the 66-1 MDC system, specific portions of this system should be interrogated to extract only the information needed to exercise the model. Procedures for facilitating this process would save time and insure complete data availability.

2. The program for computing MLEs 1-4 should be evaluated and modified as necessary to preclude manual changes and computational deficiencies. Modifications must be made to insure proper aggregation of test removals and support general data incorporation into the program.

3. A comparative analysis between application of the O&S cost model to the F-16 acquisition and the A-10 acquisition should be conducted.

APPENDIX A

INTERVIEW GUIDE FOR SPO (AFSC), AFALD, AND HQ USAF/BRMC

1. What were the objectives of the O&S cost model as applied to the A-10?

2. Did your office participate in its development?

3. What are your recommendations for future application of the O&S cost model?

4. How does the AF define LRU?

5. How was the model used to fulfill the AF objectives?

6. What data was supplied to the contractors for the computations of TLEs?

7. What data was used to compute MLEs and what techniques were used for these computations?

8. Do you have any recommendations for changes, additions or deletions in the model before it is applied in future applications?

9. How effective is/was the model in evaluating ECPs?

10. What techniques were used to apply the data to the model?

APPENDIX B

INTERVIEW GUIDE FOR CONTRACTORS

1. What benefits, or disadvantages, are there in LCC application?

2. Did the O&S cost model affect your design of the aircraft?

3. What were the AF objectives in applying the O&S cost model to the A-X/A-10 program?

4. What was your role in designing and applying the O&S cost model?

5. Did the model become an end in itself?

6. Is the model too complex?

7. Where did the data come from to develop TLEs? Do you feel the data was valid? Why? Why not?

8. How did you define LRUs? Did you get any guidance from the A-10 SPO?

9. What are your recommendations for changes, additions or deletions to the model before it is applied to future major system acquisitions?

10. How effective is/was the model in evaluating ECPs?

11. What techniques were used to apply cost data to the model?

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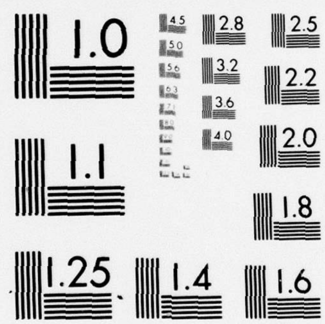

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF

APPENDIX C

INTERVIEW GUIDE FOR ALC/AFLC

1. What was your involvement with the O&S cost model as applied to the A-X/A-10?

2. How did your office interface with the contractors and the SPO in MLE computation?

3. What, if any, areas of the model are managed by your office?

4. Is the model viable?

5. What does your office use the model for?

6. Did you participate in the development of the model?

7. Does your office have any responsibility for the model's application to the A-10?

8. How does the model account for O&S costs?

9. What percentage of your work week is spent on O&S cost related items?

10. What are your recommendations for changes in the model before it is applied to future major system acquisitions?

APPENDIX D

MAINTENANCE DATA COLLECTION (MDC) SYSTEM

The United States Air Force's Maintenance Data Collection System is utilized at all levels in all commands of the Air Force. Additionally, the data contained in the MDC is provided to contractors to help formulate cost estimates for new weapon systems. The requirements for management support of MDC are provided in AFM 66-1, Volume II, Chapter 4, *Maintenance Management*. The use of the MDC system includes:

1. Refining inspection programs
2. Determination of routine modifications
3. Base level manning
4. Reliability and maintainability studies
5. Configuration management.

AFM 66-267, *Maintenance Data Collection System*, states that maintainability and reliability studies demand absolute data accuracy.

All data inputs to the various files in the MDC system are input from AF Form 1530, Punch Card Transcript; AFTO Form 349, Maintenance Data Collection Record; AFTO Form 349-3, Maintenance Data Collection Record; or a tape file from command-unique systems. The system is updated by inputs from AF Forms 1530 and AFTO Forms 349. Both these forms are handscribed documents initiated by base level maintenance squadron personnel. Data from these documents are key punched daily and input into the computer files. Two tapes are generated each month for MDC data: a month-to-date tape (ABD3BA) and a history tape (ABD6DA).

The monthly MDC transaction listings include:

1. On-equipment—PCN SGØØ1B5Ø1
2. Off-equipment—PCN SGØØ1B5Ø2
3. Support General—PCN SGØØ1B5Ø3
4. Indirect Labor—PCN SGØØ1B5Ø4
5. Parts Replaced—PCN SGØØ1B5Ø5
6. Serially-controlled and Time Change Remove and Replace—PCN SGØØ1B5Ø6
7. Engine Remove and Replace—PCN SGØØ1B5Ø7.

These listings are the basic source of all maintenance tasks performed and direct and indirect labor expended during the month. Analysis by work unit code (WUC) is the most common. This analysis includes:

1. Isolation of frequent malfunctioning components—on and off equipment maintenance.
2. Forecasting future parts requirements—parts replaced.
3. Auditing time change requirements—serially-controlled and time change remove and replace.

Additionally, MDC data provides inputs for a performance monitoring system. This system includes:

1. WUC Trend Analysis Report—PCN SGØØ1B732. This report includes:

a. total number of failures

b. off-equipment man-hours (monthly)

c. on-equipment man-hours (as a deviation from 12 month historical averages).

2. Part Number Trend Analysis Report—PCN SGØØ1B734. This report includes off-equipment maintenance information only.

3. On-Equipment Performance Hi-Lights—PCN SGØØ1B771. This report includes each WUC that has received maintenance that exceeds the average man-hours per unit. Average man-hours are computed on a continuous twelve month cycle.

4. Off-Equipment Performance Hi-Lights—PCN SGØØ1B772. This report is similar to on-equipment except that it is by FSC.

5. High-25 On-Equipment Failures—PCN SGØØ1B781. These failures are identified by WUC. Data is available on a continuous twelve month cycle.

6. High-25 Man-Hour Consuming Jobs— PCN SGØØ1B791. This listing includes total man-hours for on and off equipment maintenance by WUC.

To utilize this data for any given system, all the data tapes must be interrogated for that particular system (A-10, for instance). Both monthly and historical tapes must be included for a meaningful information flow to be established. The users may then utilize this data for whatever documentation/verification necessary, such as computing Measured Logistics Effects (MLEs), or evaluating Engineering Change Proposals (ECPs).

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9