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Life-Cycle-Cost Analysis of the Microwave Landing System Ground and Airborne Systems

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October 1981

Final Report

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16. Abstract

This report presents the results of a life-cycle-cost analysis of the Microwave Landing System ground and airborne configurations that may be implemented for the National Airspace System. The ground configurations evaluated consisted of 3°, 2°, and 1° beamwidth azimuth subsystems. The airborne configurations evaluated were for air carrier aircraft, high-performance general aviation aircraft, and low-performance general aviation aircraft.

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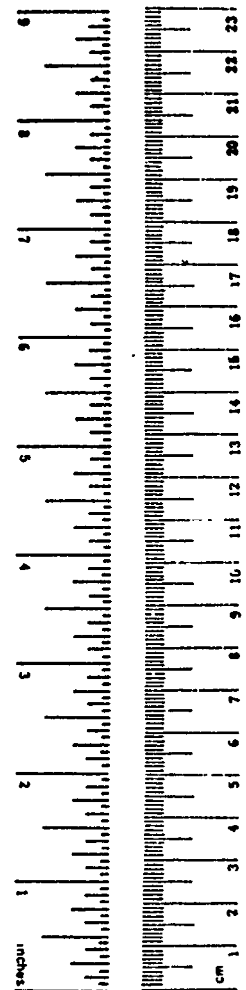
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

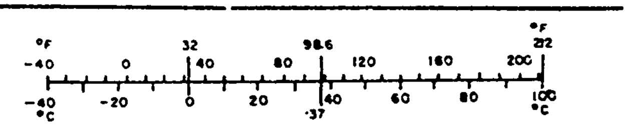
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SUMMARY

This report presents the results of a study conducted by ARINC Research Corporation to develop acquisition, installation, and life-cycle costs for ground and airborne equipments of the Microwave Landing System (MLS). The study was conducted for the Federal Aviation Administration (FAA) Systems Research and Development Service (SRDS) and Office of Systems Engineering Management (OSEM) under Contract DOT-FA76WA-3788.

Costs were developed for four ground MLS configurations and three airborne MLS configurations. The four ground configurations and their characteristics are shown in Table S-1. All costs were based on existing prototype designs; minor modifications were made to the designs where appropriate to incorporate state-of-the-art technology. Acquisition costs and equipment mean time between failures (MTBF) were developed through the use of a parametric pricing model that used input data developed by ARINC Research through detailed analysis of the prototype equipments. ARINC Research developed equipment installation costs and derived life-cycle costs (LCCs) of the ground and airborne equipment with the use of ARINC Research-developed economic analysis models.

Tables S-2 through S-4 summarize the cost analysis for the MLS ground equipment. Table S-2 presents the unit costs for the MLS ground configuration in constant 1980 dollars, with a production rate variability. Table S-3 presents the life-cycle costs by MLS configuration and total system implementation for a 25-year life cycle. The costs in Table S-3 are dependent on the implementation and maintenance scenario selected. We used implementation strategy 9 from the FAA's *Draft Precision Approach System Transition Plan* of 7 June 1979. Under this strategy, the system configurations listed in Table S-3 were acquired and deployed. The number of back azimuth systems deployed was an assumption of the LCC study. The maintenance scenario chosen for the study was the 80's maintenance concept, which used centralized maintenance hubs and remote maintenance monitors. Table S-4 presents the LCC study results in discounted 1980 dollars.

A sensitivity analysis was also performed to determine the sensitivity of the ground system LCC to the following:

- Variations in system MTBF data
- Shelters versus weatherproof enclosures for Basic I MLS sites

Table S-1. EQUIPMENT CONFIGURATIONS CONSIDERED DURING STUDY

Considerations	Configurations by Reliability and Integrity Categories			
	I		II	III
	SCMLS	Basic I	Basic II	Expanded
Equipment Costs To Be Determined	Azimuth electronics Azimuth antenna Elevation electronics Elevation antenna controls Remote maintenance monitor (RMM)	Azimuth electronics Azimuth antenna Elevation electronics Elevation antenna controls Remote maintenance monitor	Dual azimuth electronics Dual elevation electronics Dual controls	[illegible] azimuth antenna
Costs To Be Assumed or Taken From FAA Data	Commercial distance-measuring equipment (DME) Back azimuth same as front azimuth (installed at 10 percent of installations)	Precision DME Back azimuth same as front azimuth (installed at 20 percent of installations)	Azimuth and elevation antennas same as Basic I RMM same as Basic I Dual DME from FAA	All other equipment same as Basic II
System Characteristics	Azimuth beamwidth - 3° Elevation beamwidth - 2° Proportional azimuth - ±10° Sector azimuth - 40° Proportional elevation - 1° to 15° Range - 20 nmi	Azimuth beamwidth - 2° Elevation beamwidth - 1° Proportional azimuth - ±40° Proportional elevation - 1° to 15° Range - 20 nmi	Same as Basic I	Same as Basic II, except azimuth beamwidth - 1° Proportional azimuth - ±60°
Packaging	Weatherproof enclosure	Shelters	Shelters	Shelters

Table S-2. MLS UNIT COSTS WITH PRODUCTION RATE VARIABILITY OVER A THREE-YEAR PRODUCTION RUN (MILLIONS OF CONSTANT 1980 DOLLARS)								
System Type	Production Quantities and Costs							
	75 Systems		110 Systems		145 Systems		180 Systems	
	Systems Produced	Unit Cost	Systems Produced	Unit Cost	Systems Produced	Unit Cost	Systems Produced	Unit Cost
SCMLS	75	203,300	110	194,400	145	188,800	180	184,900
Basic I	55	410,400	81	384,800	106	372,100	132	361,800
Basic II	13	602,900	1[illegible]	568,400	25	550,300	31	535,800
Expanded	7	700,000	10	648,200	14	616,400	17	593,700

- Variations in small community MLS (SCMLS) azimuth beamwidths and coverages
- Implementation strategies
- Production schedules for MLS equipment

The LCC was determined to be relatively insensitive to changes in MTBF. This was expected, because under the centralized maintenance scenario maintenance costs are not a dominating cost driver in the LCC. The limited evaluation of shelters versus weatherproof enclosures determined that acquisition costs could be reduced by approximately 10 percent, installation costs by 13 percent, and total life-cycle costs by 11 percent if weatherproof enclosures are used instead of shelters. The reduction in LCC is based in part on the assumption that shelters have an MTBF of 15 years.

In evaluating the SCMLS azimuth configuration, we concluded that a change in beamwidth from 3° to 2° would result in an increase in the LCC of approximately 3 percent. A change in coverage from 10° to 40° would increase the LCC by 9.5 percent, and a 2° beamwidth, 40° coverage configuration would increase the LCC by approximately 15 percent. These results are valid only for the configuration evaluated.

We evaluated various implementation strategies during the sensitivity analysis and found that a faster implementation rate would result in an increase in recurring costs, because these costs are time- and MTBF-dependent. With constant dollars there would be no change in acquisition, installation, or nonrecurring costs. Implementation of a single system would show a reduction in nonrecurring costs, because a smaller amount of initial spares and data would be required.

An evaluation of production capacity showed that if two manufacturers produced approximately 25 systems per year instead of one manufacturer producing approximately 50 systems per year, the total LCC would increase by approximately 27 percent. Production capacity was evaluated for the SCMLS configuration only. The results showed that with two manufacturers, 8 percent would be added to the LCC acquisition cost, 100 percent to the LCC nonrecurring logistics costs, and 54 percent to the recurring logistics costs. These results are valid only for the assumptions governing them.

Table S-3. TWENTY-FIVE-YEAR LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS OR 180 BASIC SYSTEMS (MILLIONS OF CONSTANT 1980 DOLLARS)

Cost Category	Cost by System Type						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	88.149	3.229	172.930	[illegible]	103.754	37.911	420.352
Installation	89.498	0.635	120.826	2.[illegible]09	48.956	[illegible]	282.535
Nonrecurring Logistics	24.704	2.386	22.977	2.850	20.9[illegible]8	18.726	92.551
Recurring Logistics	84.020	5.191	148.263	15.845	75.336	43.[illegible]0	372.375
Total	286.371	11.441	464.996	[illegible].383	[illegible]48.954	120.668	1,167.813

Table S-4. TWENTY-FIVE-YEAR LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS OR 180 BASIC SYSTEMS (MILLIONS OF DOLLARS, USING A DISCOUNT RATE OF 10 PERCENT)

Cost Category	Cost by System Type						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	28.809	1.085	52.684	4.308	22.653	10.201	119.740
Installation	24.173	0.176	30.422	0.572	8.834	4.517	68.694
Nonrecurring Logistics	1[illegible]01	1.163	8.732	1.243	8.057	8.223	38.919
Recurring Logistics	14.282	1.018	23.353	2.767	11.087	7.672	60.179
Total	78.765	3.442	115.191	8.890	50.631	30.613	287.532

Acquisition costs and expected quantities of equipment for the airborne MLS system are shown in Tables S-5 through S-7. The values indicate the probable selling price of the avionics to prospective users. Appropriate markups for distribution have been included on the basis of known or expected practices of the avionics manufacturers. All costs are based on constant 1980 dollars. Tables S-8, S-9, and S-10 present the LCC of the MLS avionics over a period of 21 years by user community for both new and retrofit installations for the equipments shown in Tables S-5 through S-7. The unit acquisition cost shown in Table S-10 for low-performance general aviation aircraft is different from the acquisition cost illustrated in Table S-7, because the LCC allows for the normal distributor discount if the distributor installs the avionics in the aircraft.

Table S-11 shows the life-cycle costs for the entire aviation community in constant 1980 dollars. Table S-12 presents the results of Table S-11 in discounted 1980 dollars. The individual aircraft owner costs are likely to be of the most interest to the general aviation community, while the air carrier community will probably be more concerned with the cumulative costs of system implementation.

Table S-5. AIR CARRIER AVIONICS COST PER MLS INSTALLATION, BASED ON 500 UNITS PER YEAR (1980 DOLLARS)

Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	2	8,880	17,760
MLS Control Panel	2	1.026	2,052
MLS Auxiliary Data Display	1	2,539	2,539
C-Band Antenna	2	150	300
Precision DME	1	11,385	11,385
Computer Interface	1	1,500	1,500
Total			35,536

Table S-6. HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT AVIONICS COST PER MLS INSTALLATION, BASED ON 1,000 UNITS PER YEAR (1980 DOLLARS)			
Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	1	7,219	7,219
MLS Control Panel	1	923	923
C-Band Antenna	1	195	195
L-Band Antenna	1	117	117
Conventional DME	1	5,850	5,850
CDI Display	1	916	916
Total			15,220

Table S-7. LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT AVIONICS COST PER MLS INSTALLATION, BASED ON 1,000 UNITS PER YEAR (1980 DOLLARS)			
Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	1	1,648	1,648
C-Band Antenna	1	346	346
CDI Display	1	600	600
Total			2,594

Table S-8. COST OF OWNERSHIP FOR COMMERCIAL AVIATION AIRCRAFT (1989 TO 2009)

Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition	35,536	35,536
Installation	6,940	11,560
Nonrecurring Logistic	10,032	10,032
Recurring Logistic (First Year)	1,469	1,469
First Year of Ownership	53,977	58,597
Life-Cycle Cost	63,357	87,977

Table S-9. COST OF OWNERSHIP FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT (1989 TO 2009)

Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition	15,220	15,220
Installation	5,860	9,770
Recurring Logistic (First Year)	135	135
First Year of Ownership	21,215	25,125
Life-Cycle Cost	23,915	27,825

Table S-10. COST OF OWNERSHIP FOR LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT (1989 TO 2009)		
Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition*	2,075	2,075
Installation	195	325
Recurring Logistic (First Year)	10	10
First Year of Ownership	2,280	2,410
Life-Cycle Cost	2,460	2,590

*Cost is discounted to allow for distributor installation.

Table S-11. CUMULATIVE LIFE-CYCLE COSTS FOR MLS IN MILLIONS OF CONSTANT 1980 DOLLARS (1989 TO 2009)				
Cost Category	Cost by Aircraft Avionics Category			Total
	Low-Performance General Aviation*	High-Performance General Aviation**	Commercial Aviation†	
Acquisition	266.476	501.132	185.320	952.928
Installation	26.405	233.996	49.128	309.529
Nonrecurring Logistic	9.384	27.980	42.254	79.618
Recurring Logistic	12.371	45.905	119.388	177.664
Total	314.636	809.013	396.090	1,519.739

*117,900 new installations; 10,500 retrofit installations.
**22,425 new installations; 10,500 retrofit installations.
†2,415 new installations; 2,800 retrofit installations.

Table S-12. CUMULATIVE LIFE-CYCLE COSTS FOR AIRBORNE MLS IN MILLIONS OF DISCOUNTED 1980 DOLLARS (1989 TO 2009)				
Cost Category	Cost by Aircraft Avionics Category			Total
	Low-Performance General Aviation	High-Performance General Aviation	Commercial Aviation	
Acquisition	44.354	86.775	51.023	182.152
Installation	4.430	41.297	15.186	60.913
Nonrecurring Logistic	1.701	4.916	12.680	19.297
Recurring Logistic	1.521	5.774	19.408	26.703
Total	52.006	138.762	98.297	289.065

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

For the past 10 years, the Federal Aviation Administration (FAA) has been engaged in the development of the Microwave Landing System (MLS) as a replacement for the Instrument Landing System (ILS) currently deployed at more than 500 airports. The ILS has done an excellent job of meeting precision landing requirements for the National Airspace System during the past 35 years, but it has some inherent limitations that are expected to become increasingly serious in the near future. Inadequate channel capacity, the inflexibility of the approach path that aircraft must follow, and the impact that terrain and weather have on the effectiveness of the system, among other considerations, limit the potential growth of the ILS. The MLS program either eliminates or alleviates all of these problems.

Early introduction of the MLS is desirable so that precision-approach capability may be provided at airports not suitable for ILS operation. Many of these airports serve the growing commuter and general aviation population and must improve their instrument capability to ensure the safety of the aviation community. Since travel patterns indicate that aircraft using the smaller community airports often also land at major commercial airports, a compatible MLS must be provided at the large airports.

The basic MLS has been designed to meet the requirements of both commercial and general aviation aircraft. Introduction of the MLS at major airports will provide precision approach to all users while allowing the phased replacement of the ILS with the MLS.

The FAA plans to install approximately 1,200 MLSs nationwide between 1985 and 2005. MLSs will eventually replace existing ILSs to provide an improved, cost-effective precision-approach capability. The MLS has reached the preproduction prototype stage; consequently, satisfactory technical information is now available to permit a detailed cost analysis of the expected life-cycle cost (LCC) of the MLS, including design, manufacture, and implementation.

The Systems Research and Development Service (SRDS), in conjunction with the Office of Systems Engineering Management (OSEM) of the FAA, tasked ARINC Research Corporation, under Contract DOT-FA76WA-3788, to develop the life-cycle costs for a family of MLS ground and airborne equipment in accordance with the November 1980 *Program Plan for a Life-Cycle-Cost Study of the Microwave Landing System.*

1.2 CONTRACT OBJECTIVES

The primary objective of the contract effort was to develop and evaluate detailed cost data on MLS ground and airborne equipments. The equipments costed were based on existing prototype designs updated to 1980 technology. The study addressed costs associated with the acquisition, installation, operation, and support of the proposed equipments. Ground equipments were combined to establish the total cost of ownership to the FAA, and airborne equipments were combined to establish the total cost of ownership to both the individual operator and the entire aviation community. Separate cost data were developed for four classes of ground equipment and three classes of airborne equipment.

1.3 PROJECT OVERVIEW

Over the past decade, the FAA has conducted a series of studies involving prototype MLSs. Those studies have shown that the MLS provides a number of operational and cost benefits to the user community. The purpose of the study by ARINC Research was to analyze the LCC of the MLS. The analysis took into account the current electronic state of the art as applied to the MLS.

This study was designed to meet the following objectives:

- On the basis of the prototype MLS, define an updated production version of the MLS, taking into account such components as microprocessors and large-scale integrated circuits.
- Develop an implementation schedule for the MLS and a concomitant production schedule.
- Develop and exercise an LCC model that, when integrated with implementation and production schedules, will yield the total national LCC.

The LCC developed under this program was limited to the cost of implementing the MLS without regard for how costs may be reduced because of existing ILS installations, cables, power availability, and roads. The cost benefits of the MLS were reported in *An Analysis of the Requirements for, and the Benefits and Costs of, the National Microwave Landing System (MLS)*, FAA Report EM-80-7 of June 1980. ILS terms such as Category I, II, and III used in this report describe the reliability and integrity of a system rather than an operational characteristic. The MLS has been designed to provide sufficient accuracy to permit automatic landings at any MLS site. Categories of landing minimums at any MLS site will be determined by factors other than accuracy.

Since the implementation strategy used in the LCC study directly affects overall costs, the economic analysis model (EAM) used for the study was designed with adequate flexibility to allow evaluation of different implementation strategies. In addition, the EAM was exercised to determine cost sensitivity to the following variants:

- Production schedules
- Reliability improvements
- Shelters versus weatherproof enclosures for nonredundant Basic MLS sites
- Different degrees of azimuth coverage
- Different azimuth beamwidths

ARINC Research Corporation developed the costs for four MLS ground systems and three MLS airborne systems. The total ground system LCC was calculated by use of a modification to the Facility Maintenance Cost Model developed by ARINC Research under Contract DOT-TSC-1173. The total airborne system LCC was calculated by use of the EAM developed under Task 1 of this contract for the airborne Discrete Address Beacon System (DABS). This report presents the results of the cost analysis in 1980 dollars, consistent with the technology and available data from which the estimates were made.

1.4 ORGANIZATION OF REPORT

This report addresses the MLS ground and airborne configurations and the techniques used for estimating the unit and life-cycle costs of the designs, and presents the results of the analysis.

Chapter Two describes the overall approach used to develop the economic evaluations and the modeling method used to obtain the desired unit and life-cycle costs. Chapter Three describes the development of the cost data for the various MLS ground configurations evaluated. Chapter Four addresses the common parameters used in the ground LCC model, including installation costs, implementation strategy, and maintenance scenario.

Chapter Five describes the results of the MLS ground configuration LCC study, and Chapter Six presents a sensitivity analysis of them. Chapter Seven describes the development of the cost data for the various MLS avionics configurations. Chapter Eight addresses the installation costs, implementation scenarios, and maintenance scenarios used in the MLS airborne portion of the LCC study, and Chapter Nine presents the results of the airborne LCC analysis. Finally, Chapter Ten summarizes the results of the analysis and presents conclusions.

Nine appendixes appear at the end of this report. Appendix A contains detailed cost sheets associated with the MLS ground configurations, Appendix B describes the development of the ground installation costs, and Appendix C presents detailed life-cycle-cost results for the ground equipment analysis. Appendix D describes the ground LCC model, Appendix E presents the ground LCC model, and Appendix F addresses the common parameters used in the ground LCC model. Appendix G describes the airborne LCC model, Appendix H presents the airborne LCC model, and Appendix I addresses the common parameters used in the airborne LCC model.

CHAPTER TWO

APPROACH

The costs of the various ground and airborne MLS configurations were developed in a similar manner. While acquisition, installation, and logistic support costs are unique to each configuration, they may be integrated with implementation scenarios through economic analysis models to give the total life-cycle cost of the deployed systems.

Development of detailed and accurate cost analyses of equipments that currently exist only in prototype form can pose a number of formidable problems, including the following:

- Conversion of engineering requirements to the production configuration of equipment. The system concepts are in various stages of evaluation and employ existing levels of technology. Evaluation criteria used must take these limitations into account to ensure that the study evaluates production-quality equipments.
- Anticipation of the needs of new equipment. The costs of any new equipment are controlled by the demand for the product. Estimates of production quantities for cost-effective manufacturing are dependent on expected implementation schedules. The ground system implementation schedules were governed by the draft MLS transition plan; the airborne implementation schedules were dependent on the forecast aviation community.
- Development of the necessary additional data required for a comprehensive cost analysis. Development of data (such as labor hour costs) that apply equally to any MLS ground system, while of the lowest criticality in a cost analysis, is extremely important to the accurate development of total implementation cost.

Figure 2-1 illustrates the general approach followed by ARINC Research Corporation in resolving these problems and obtaining the economic evaluation of the MLS configurations.

Existing ARINC Research EAMs were adapted to evaluate the MLS implementation scenarios. Parallel data-collection efforts were initiated to obtain the common and system-peculiar input data needed to exercise the models. Common data, such as maintenance scenarios, were developed or obtained from existing FAA documents. The models were also exercised for variations of

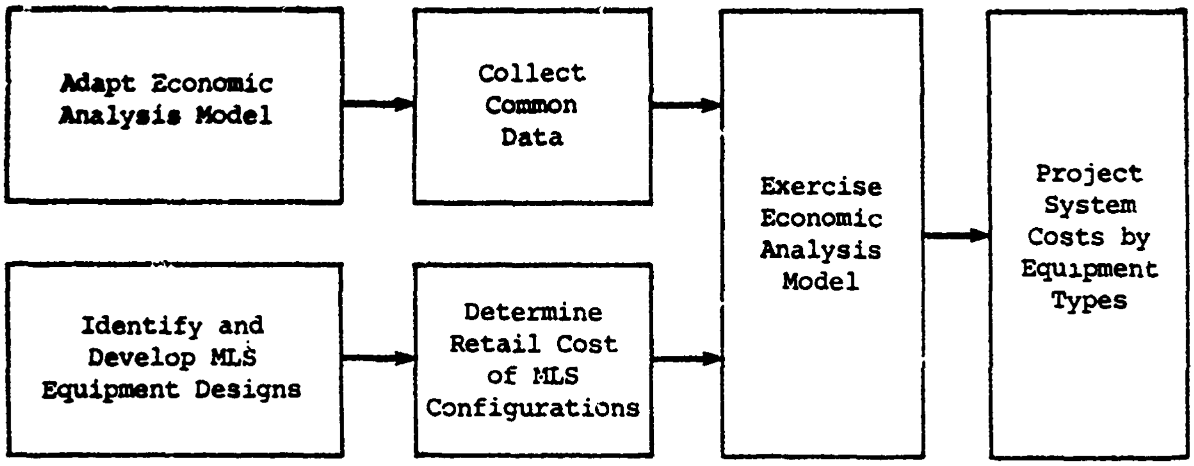

Figure 2-1. MLS ECONOMIC ANALYSIS APPROACH

key parameters so that the sensitivity of the results obtained from the input data and the assumptions employed in the analysis could be investigated. The outputs of each model exercise were the resultant acquisition, installation, support, and total costs, by MLS configuration and for the total user community, for each year and cumulatively for the 25 years from 1985 through 2009.

The remainder of this chapter presents details on how these problems were approached.

2.1 SYSTEM CONCEPT

The MLS was designed as an evolutionary replacement for the ILS. It employs ground-transmitted, time-referenced scanning beam angle information, which is decoded by an airborne receiver-processor to achieve position information. Ground and airborne distance-measuring equipment (DME) provide range information. Position and range information may be processed in an airborne computer and fed to an autopilot to allow automatic curved or segmented approaches.

2.2 ACQUISITION COST

Acquisition cost is the cost associated with the actual purchase of the equipment evaluated. Unit acquisition costs of both ground and airborne MLS equipments were calculated using the parametric method of pricing, which estimates costs on the basis of various physical and economic decriptors of the equipment being evaluated.

The model chosen for the parametric method of pricing, the RCA Programmed Review of Information for Costing and Evaluation (PRICE), requires a set of parametric data inputs that properly defines the module, or system, to be priced. The model was chosen because of its wide acceptance by the federal Government as a computer-based pricing model. Of the many input parameters required, the most critical cost-driving ones are the weight, volume, and structural-electronic division; manufacturing complexities; and markups for overhead, general and administrative (G&A) costs, and profit. Since manufacturing complexities vary among manufacturers in different fields (e.g., avionics for ARINC class or general aviation class equipments), a detailed characterization was necessary for each type of manufacturer expected to produce MLS ground or airborne equipment.

ARINC Research has studied the manufacturing complexities of several key manufacturers of electronics by thoroughly reviewing existing systems, collecting data at various manufacturing plants, and frequently exercising the PRICE model to establish the typical values for manufacturing complexities. The developed complexity factors have been compiled and are stored in ARINC Research data files. They were used as a baseline in estimating the cost of the MLS equipments considered in this study. Complexity factors for actual subassemblies were dependent on the physical inspection of each subassembly.

2.2.1 The PRICE Model

PRICE is a computerized parametric cost-modeling technique developed by RCA. It estimates development and production costs on the basis of physical and economic descriptors of the system under evaluation and compares new requirements with industrywide data bases on analogous systems. PRICE efficiently stores, retrieves, and uses this historical information, allowing the classification of new designs by relating them to past similar design efforts. The method provides the means of reducing great quantities of empirical data to a relatively small number of principal variables that can be adjusted to match the economic and technological characteristics of the specific system.

2.2.2 Model Input Data

The PRICE model requires up to 40 parametric data inputs describing the physical and economic characteristics of the system or subassembly under evaluation. When operated in the subassembly mode, the model requires similar inputs for all subassemblies and provides the means for final test and integration of the system.

The physical descriptors required include such key features as weight of the structure and its electronics, packaging densities, volumes, quantities to be produced, manufacturing complexities, and the degree of new design. Since the model is structured to provide a cost per pound on the basis of densities and complexities, it is essential that the probable weight and volume of the subassembly being evaluated is accurately determined.

To obtain these descriptors, we reviewed the existing technical descriptions of the prototype ground systems built by Bendix Communications Division of Towson, Maryland, and Hazeltine Corporation of Huntington, New York. We measured and weighed the subassemblies and MLS ground equipment at Washington National Airport (Basic); NASA Wallops Island, Virginia (wide azimuth, COMPACT™ elevation); and the Hazeltine factory at Huntington, New York (small community MLS). The same analysis was conducted for the airborne equipment at CALSPAN, Buffalo, New York (NASA Ames low-cost receiver); and FAA Technical Center, Atlantic City, New Jersey (Bendix receiver-processor).

The economic descriptors required include such features as year of production, escalation rates, engineering schedules, production schedules, and management activities required during development and production. Schedules were carefully selected, because the final costs developed by the model are affected by the complexity of a product and the time allowed for its development and production. An 18-month development cycle and a 3-year production run were used for the ground equipment. The development cycle for the airborne equipment was 12 months, and the production run was 3 years. Since the study was performed in constant 1980 dollars, the escalation rates were set to zero. Production quantities were treated as a variable. Other costs, such as those for management, tooling, and test equipment, were normalized to the RCA data bank and altered through sensitivity analyses and adaptation to specific manufacturers.

Table 2-1 lists the key input parameters in the format used throughout the study and defines abbreviations and acronyms to provide an insight into the parametric data employed by the model.

2.2.3 Model Output Data

The RCA PRICE model performs a series of evaluations based on the input parametric data and provides costs as a function of the elements associated with engineering and manufacturing for both development and production of a system or subassembly. Engineering costs include the cost of drafting, design, system management, project management, and data documentation required during system development and production. These costs are presented for the entire production quantity for the development and production period on the basis of the data input parameter set; they include the effect of learning. Manufacturing is concerned primarily with the production of a system, but also includes costs for prototype development and special tools or test equipment that might be required during development. As is the case with engineering costs, output costs are for the entire production quantity with no escalation.

During execution of the program, the model frequently compares schedules, packaging densities, and other key input parameters with historical data in the RCA data banks. Abnormal inputs, such as development periods that are too short, are flagged and brought to the attention of the operator.

The header of the output data sheet contains all the information used as the parametric input to the model. The output data sheet also provides the key parameters used in deriving the costs so that the results may be

Table 2-1. KEY PRICE PHYSICAL AND ECONOMIC DESCRIPTORS	
Descriptor Acronym or Abbreviation	Description
QTY	Total quantity to be produced
WT	Weight of assembly (subassembly), in pounds
VOL	Volume of assembly (subassembly), in cubic feet
WS	Weight of structure (nonelectronic) of assembly, in pounds
MCPLXS	Manufacturing complexity for structure
NEWST	Percent of new design required for structure
MCPLXE	Manufacturing complexity for electronics
NEWEL	Percent of new design required for electronics
CMPNTS	Number of electronic components
ECMPLX	Engineering complexity of assembly (subassembly)
PRMTH	Production period, in months
LCURVE	Production learning curve
ECNE	Engineering change orders for electronics, in percent
ECNS	Engineering change orders for structure, in percent
YEAR	Year of technology (usual start of design or production)
ESC	Escalation rate, in percent
PROJCT	Degree of project management support during engineering
DATA	Degree of data requirements
TLGTST	Degree of special tools and test equipment required for development
PLTFM	Factor for reliability testing, specification severity
SYSTEM	Degree of system engineering required
PPROJ	Degree of project management support during production
PDATA	Degree of data required during production
PTLGTS	Degree of special tools and test equipment required for production

checked. In addition, it provides the expected cost estimated by the program, bounded by approximately two-sigma level-of-confidence costs.

PRICE also predicts the expected mean time between failures (MTBF) of the equipment. The MTBF for each equipment was compared with the prototype equipment manufacturer's predicted MTBF to determine their adequacy for use in the study. Where a wide disparity existed between the two predicted MTBFs, we checked the values against the Government-Industry Failure Rate Data Exchange (GIFRDE) program to determine the value to be used.

2.3 DEVELOPMENT OF ECONOMIC ANALYSIS MODELS

The specific means of assessing the projected costs associated with each of the MLS configurations was through the development and exercise of computer-based EAMs. These models determined the annual and cumulative costs associated with each type of MLS system and tabulated these costs by equipment and for the total user community. The models were developed by tailoring existing ARINC Research cost models to the specific characteristics of the MLS implementation concepts and the aviation community.

Input data to the EAMs consisted of data unique to a particular MLS configuration being evaluated and data common to all MLS configurations being evaluated. The specific requirements for each type of data were defined as the model was developed, and required data were collected. The models were then exercised for each system concept in the user community. In addition, the EAMs were exercised to determine the sensitivity of the results to variations in key parameters (e.g., MTBF).

2.4 LCC STUDY ASSUMPTIONS

Many assumptions must be made in the course of an LCC analysis. The assumptions from the MLS LCC program plan are presented in the following subsections to provide a ready reference to the baseline LCC scenario. Deviations from the program plan assumptions are parenthetically noted.

2.4.1 General Assumptions

The following general assumptions were made for the LCC analysis:

- Cost figures will be commensurate with solid-state components.
- The designs will make maximum use of 1980 technology.
- Components used will meet the quality standards of FAA 2100 where applicable.
- The transition period will be 1985 to 2005. Implementation will begin in 1985, with the first system deployed in 1987.
- Constant fiscal 1980 dollars will be used to calculate the costs.
- A discount rate of 10 percent will be applied in accordance with Executive Office of Management and Budget (OMB) Circular A-94.

- The cost models will compute annual and cumulative values in each major cost element for each equipment class.
- The ground LCC model will be adapted from the Facility Maintenance Cost Model developed under Contract DOT-TSC-1173.
- The air LCC model was developed under Contract DOT-FA74WA-3506 and updated under Contract DOT-FA76WA-3788.

2.4.2 Acquisition Cost Assumptions

The acquisition cost assumptions were as follows:

- Costs will be generated with the RCA PRICE model and compared with cost estimates of hardware manufacturers.
- A learning curve of 87.5 percent will be used. (Ground equipment manufacturers normally use a learning curve of 92 percent, so 92 percent was used for ground equipment.)
- Complexity-factor decisions for PRICE inputs will be based on ARINC Research experience.
- Ground equipment production quantities will be determined by the implementation schedule.
- Commercial aviation production quantities will be 500 units per year per manufacturer.
- General aviation production quantities will be 1,000 units per year per manufacturer.
- Costs of marker beacons will be based on current FAA costs. (Marker beacon costs were not used.)
- DME costs will be based on current FAA costs.
- Precision DME costs will be estimated as an incremental cost over standard DME.

2.4.3 Installation Cost Assumptions

The following installation cost assumptions were made for the ground and avionics systems:

- Ground Systems
  - A total of 1,177 systems will be installed over 20 years -- from 1987 to 2006.
  - Standard construction manual national average trenching costs will be used for the LCC.
  - The MLS types required will be determined from the FAA data base used for the transition plan.
  - When shelters are used, the unit cost will be at current FAA prices.

- - Flight-check and certification costs will be based on current ILS procedures and MLS engineering flight checks.
  - Only split-site configurations will be evaluated.
  - Basic and Expanded back azimuth sites will be obtained by reconfiguring front azimuth sites.
  - Approach lights will not be costed.
  - Ten percent of SCMLS installations will have back azimuth capability.
  - Twenty percent of Category I Basic installations will have back azimuth capability.
- Avionics Systems
  - Avionics retrofit installation costs will be taken from *Development of Avionics Retrofit Installation Costs in Air Carrier and General Aviation Aircraft*, FAA Report EM-79-14 of November 1979.
  - Installation costs in new aircraft will be assumed to be 60 percent of retrofit costs.
  - Full deployment for commercial air carriers will require four years -- from 1989 to 1993.
  - General aviation aircraft will be retrofitted according to the information in Table 8-5.
  - The number of aircraft installations involved will be based on data shown in Table 8-5.
  - After the start date of 1989, all commercial aircraft will have MLS equipment installed during manufacture.
  - The expected installation rates for new general aviation aircraft will be based on information presented in Section 8.4.

2.4.4 Operations and Maintenance Cost Assumptions

The following operations and maintenance cost assumptions were made for the ground and avionics systems:

- Ground Systems
  - The average operating hours per month will be based on the system's operating 24 hours per day.
  - Equipment MTBF will be determined by the PRICE model.
  - The minimum number of spares will be one per organization.
  - The stocking objective for nonrepairables will be in accordance with FAA practice.
  - Average pipeline factors will be in accordance with FAA data.

- - On-system maintenance costs for ground systems will be assumed to be 4.75 hours per centralized maintenance action.
  - Twelve weeks of specialized MLS training will be required.
  - Three days per year of recurring MLS maintenance training will be provided.
  - There will be 75 hubs for centralized maintenance.
  - There will be four levels of module repair -- discard and replace, a central repair group at the hub, depot, and on-site.
- Avionics Systems
  - Air carriers will apply current maintenance practices to the MLS equipment.
  - Average operating hours for aircraft will be based on the information in Table 8-5.

2.5 APPROACH SUMMARY

The preceding sections have provided an overview of the technical approach used in the study, outlined the capabilities of the EAMs, described their use, and identified the general types of data and assumptions used in the evaluation. The succeeding chapters of this report describe in detail the MLS configurations, the acquisition costs, the characteristics of the EAMs, and the specific results of the study.

CHAPTER THREE

MLS GROUND SYSTEM CONFIGURATIONS ACQUISITION COSTS

Introduction of the MLS ground systems into the National Airspace System will result in an investment cost that is dependent on the ground equipment configurations deployed. This chapter identifies the capabilities recommended by the FAA and evaluates the acquisition costs associated with each ground system configuration. Acquisition costs consider the actual cost of equipment. Costs such as factory inspections, documentation, training, and spares are considered in Section 5.3.1.

3.1 SYSTEM CONFIGURATIONS

3.1.1 General

The MLS signal format defined in FAA MLS Engineering Requirement ER-700-08C, *Microwave Landing System (MLS) Signal Format and System Level Functional Requirements,* ensures compatibility between ground system elements and allows a variety of system elements to be installed at any given facility. On the basis of the MLS prototype development program, three configurations of MLS azimuth and elevation beamwidth combinations were defined to satisfy the operational requirements of the MLS in the United States. The three configurations are shown in Table 3-1.

Table 3-1. MLS BEAMWIDTH COMBINATION CONFIGURATIONS

Configuration	Azimuth Beamwidth	Elevation Beamwidth
1	3°	2°
2	2°	1°
3	1°	1°

These configurations use similar equipment, but differ in proportional coverage specifications, reliability and integrity of equipment, and functions to be provided. All three configurations include the following:

- Approach azimuth equipment (for lateral guidance)
- Approach elevation equipment (for vertical guidance)
- DME
- Means for transmitting basic data words
- Associated monitors, remote controls, and indicator equipment for the items pre·iously listed

An Expanded MLS configuration may be derived from these Basic configurations by adding one or more of the following functions:

- Back azimuth equipment
- Flare elevation equipment (not included in this analysis)
- Means for transmitting auxiliary data
- A proportional guidance sector wider than the minimum specified
- Associated monitors, remote controls, and indicator equipment for the items previously listed

FAA ER-700-08C allows azimuth and elevation beamwidths and coverage to exist within a range of values, in effect allowing a family of MLS equipments to exist.

3.1.2 Equipment Configurations

The FAA Technical Data Package (TDP) governing the transition of the MLS program from Systems Research and Development Service (SRDS) to Airways Facilities Servi-e (AAF) recommends two production MLS configurations -- a Basic configuration and a small community configuration (SCMLS). Accordingly, a SCMLS and·a Basic MLS configuration were used for this study as stipulated in the November 1930 *Program Plan for a Life-Cycle-Cost Study of the Microwave Landing System.* In addition, two variations of the Basic MLS were evaluated, which used similar equipment but differed in beamwidth or operational availability of the equipment. Because of the variations in Basic equipment, the Basic II system was defined to be the same as the Basic I, but with dual electronics. This would be a Category II system with respect to the reliability and integrity built into the system. The Expanded system is the same as the Basic II, but the azimuth beamwidth was reduced to 1° from 2°, and the coverage was increased to ±60°.

Table 3-2 shows the characteristics and limitations of the four configurations costed, as well as the equipment costs to be determined as part of this study and the equipment costs taken from FAA acquisition data.

Table 3-2. EQUIPMENT CONFIGURATIONS CONSIDERED DURING STUDY

Considerations	Configurations by Reliability and Integrity Categories			
	I		II	III
	SCMLS	Basic I	Basic II	Expanded
Equipment Costs To Be Determined	Azimuth electronics Azimuth antenna Elevation electronics Elevation antenna controls Remote maintenance monitor (RMM)	Azimuth electronics Azimuth antenna Elevation electronics Elevation antenna controls Remote maintenance monitor	Dual azimuth electronics Dual elevation electronics Dual controls	1° azimuth antenna
Costs To Be Assumed or Taken From FAA Data	Commercial distance-measuring equipment (DME) Back azimuth same as front azimuth (installed at 10 percent of installations)	Precision DME Back azimuth same as front azimuth (installed at 20 percent of installations)	Azimuth and elevation antennas same as Basic I RMM same as Basic I Dual DME from FAA	All other equipment same as Basic II
System Characteristics	Azimuth beamwidth - 3° Elevation beamwidth - 2° Proportional azimuth - $\pm 10°$ Sector azimuth - 40° Proportional elevation - 1° to 15° Range - 20 nmi	Azimuth beamwidth - 2° Elevation beamwidth - 1° Proportional azimuth - $\pm 40°$ Proportional elevation - 1° to 15° Range - 20 nmi	Same as Basic I	Same as Basic II, except azimuth beamwidth - 1° Proportional azimuth - $\pm 60°$
Packaging	Weatherproof enclosure	Shelters	Shelters	Shelters

3.1.2.1 Visibility Categories

FAA ER-700-08C defines an accuracy required at the threshold of any MLS without regard to visibility categories (I, II, or III). However, visibility categories affect the MLS ground equipment with respect to the reliability and integrity built into the system. Since the Basic I equipment shown in Table 3-2 is nonredundant, it would be considered Category I equipment. Basic II equipment was developed by considering dual electronics with a single antenna. The Expanded MLS uses the same electronics as the Basic II, but an additional cost is associated with the 1° azimuth beamwidth.

3.1.2.2 Back Azimuth

Back azimuth guidance can be used with any MLS configuration. On the basis of conversations with FAA personnel, we assumed that 10 percent of all SCMLS and 20 percent of all Category I Basic sites would have a back azimuth system installed. The back azimuth antennas would be similar to the front azimuth antennas at each site; therefore, the costs were considered to be the same.

In accordance with FAA direction, it was assumed that all Category II Basic and Category III Expanded sites would have MLS sites on the opposite end of the runway, and that these sites would be capable of being reconfigured to provide the back azimuth function.

3.1.3 Production Ground Equipment

Production MLS ground equipment was developed on the basis of the prototype Bendix Basic MLSs installed at Washington National Airport and NASA Wallops Island, Virginia, and the SCMLS at Hazeltine Corporation. This approach was chosen because the prototype equipments use two different design concepts -- conventional (full) phased array versus thinned phased array -- and demonstrate the capability of meeting the MLS design requirements. While the ground equipments of this study may not incorporate the overall design approach of the future, they do incorporate the design approach of the present.

Available documents on the prototype ground systems were reviewed and compared with FAA ER-700-08C change 1 of 16 May 1980 to identify changes that could be made in systems design. Subsystems of the prototypes that met the functional requirements of that document were reviewed to ensure that the designs reflect the latest available technology. Subassemblies were identified as candidates for technological enhancement, and state-of-the-art technology in such fields as microprocessors and integrated circuits was incorporated into the subsystems to become part of the total data package for cost evaluation where appropriate. The final designs were adapted to a parametric evaluation by a commercially available pricing model. The adaptation had a modular structure to permit independent cost analysis of subassemblies at the smallest-repairable-unit level as well as at the integrated-system level.

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3.1.3.1 Small Community MLS

The production SCMLS that was priced was a 3° azimuth, 2° elevation MLS using a thinned array. The electronics were updated with the printed circuit board (PCB) redesigns currently being incorporated into the SCMLS enhancement program. The electronics and power supplies for each subsystem were incorporated into the enclosures housing the antenna elements.

The design for our production version of the SCMLS was very similar to the prototype designs. One design improvement was the installation of a 10-watt, solid-state military specification transmitter on the equipment. The cost and MTBF of the transmitter were determined on the basis of discussions with several manufacturers of solid-state amplifiers. A 10-watt, solid-state commercial specification transmitter is currently being built by one manufacturer. Another design improvement was the use of PIN diode phase shifters rather than ferrite phase shifters. The phase shifters used external drivers. The production version of this SCMLS incorporated 10 phase shifters, 40 radiating elements, 5 dummy elements, and 7 additional elements for left/right clearance and sector identification antennas. A collapsible, canvas-and-frame structure was attached to each antenna structure for use as a maintenance shelter.

The SCMLS equipments incorp. [illegible] uninterruptible power supplies, maintenance monitors, and data communications equipment within the azimuth and elevation subsystems. The complete SCMLS configuration that was costed included azimuth and elevation field monitors, commercial nonprecision DME, and a remote control/status unit in the tower, along with a remote status unit. When a back azimuth subsystem was used, it was considered to be identical to the SCMLS azimuth subsystem. A block diagram of the SCMLS is shown in Figure 3-1.

3.1.3.2 Basic MLS

The production Basic MLS that was priced was a 2° azimuth, 1° elevation MLS with separate shelters for electronics. The electronics were based on the Basic wide electronics, with suitable changes to reflect coverage of $\pm 40°$. The 1° elevation antenna was based on the COMPACT™ MLS elevation antenna at NASA Wallops Island.

The azimuth antenna was a 2° phased array antenna (full array) incorporating 50 phase shifters and 50 radiating elements. Two dummy elements were on either end of the array, for a total of 54 elements. This antenna configuration had to be developed, because the 2° azimuth MLS at Washington National Airport is a lens-type antenna. The number of elements required was derived from the following equations:

$$\text{Number of elements} = \frac{60\lambda}{D \times \Theta_{BW}}$$

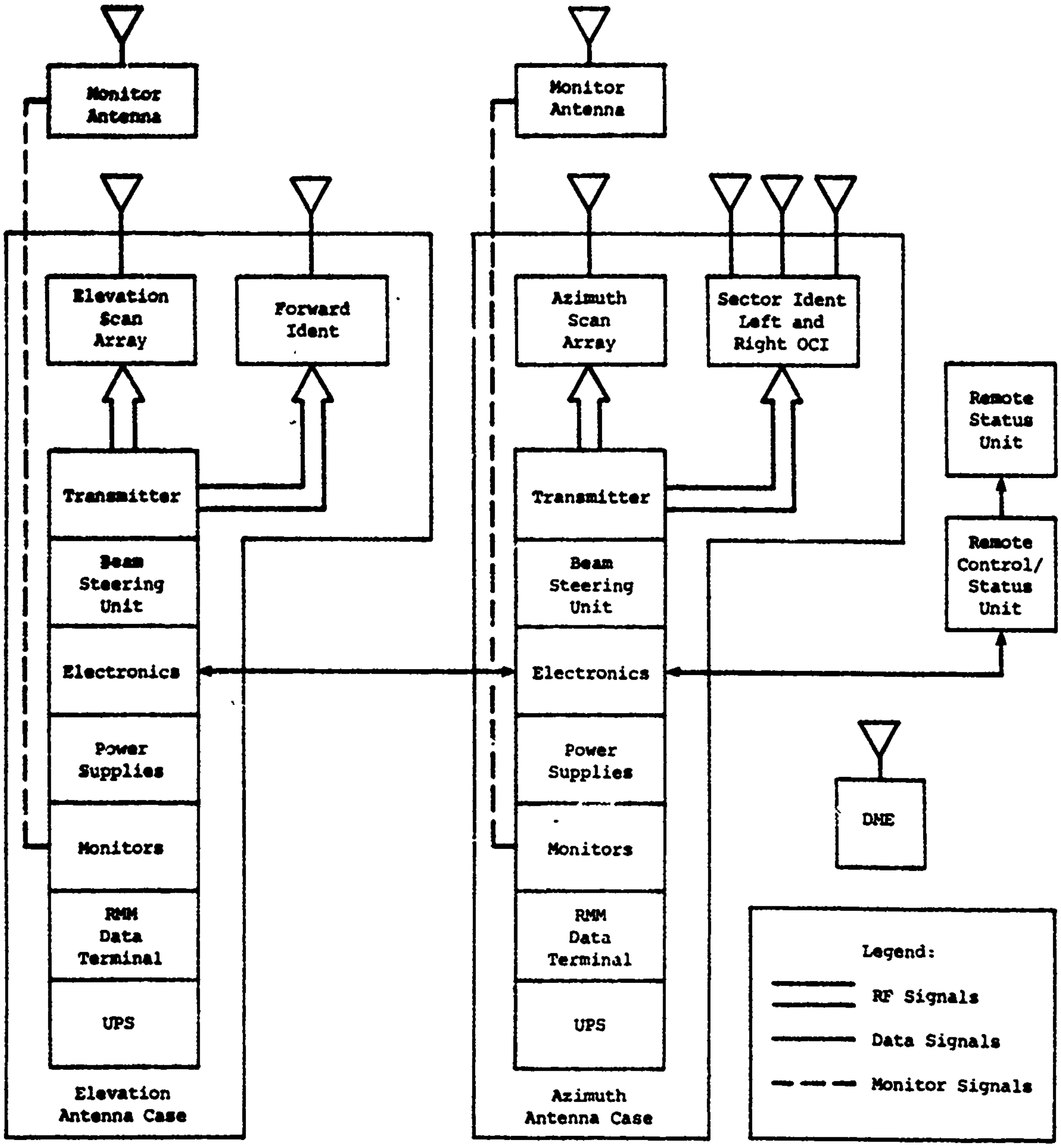

Figure 3-1. REPRESENTATIVE BLOCK DIAGRAM OF SCMLS CONFIGURATION

$$\text{Element spacing (D)} = \frac{\lambda}{1 + \text{Sin (coverage)} + (0.6 \times \text{Sin } \Theta_{BW})}$$

$$\text{Aperture width} = \frac{60\lambda}{\Theta_{BW}}$$

For a 2° beamwidth (Θ_{BW}) and 40° coverage, 50 elements were required. Two dummy elements were added to the end of the array for edge effects. We used a 50-port power divider in the antenna similar to the 116-port power divider used in the Basic wide MLS at NASA Wallops Island. The beam steering unit (BSU) assembly used in the antenna was also similar to that of the Basic wide MLS, but fewer electronics were required.

One design improvement was the replacement of the traveling wave tube and RF assembly on the Basic system with a 20-watt, solid-state transmitter built to military specifications. While no 20-watt, solid-state transmitters are currently being built for MLS frequencies, we extrapolated a cost and MTBF from existing transmitters on the basis of our conversations with manufacturers of solid-state amplifiers. In addition, 4-bit PIN diode phase shifters were used in the Basic MLS with integral drivers, control, and monitor circuits.

The Basic MLS electronics were located in a separate shelter with the precision DME. All the control and monitor electronics were contained in a single cabinet, which also contained the electronics and monitor power supplies. The BSU electronics were located in the antenna enclosure with required power supplies.

The Basic MLS equipment incorporated uninterruptible power supplies, maintenance monitors, and data communications equipment within the azimuth and elevation subsystems. The complete Basic MLS configuration that was costed included azimuth and elevation shelters, azimuth and elevation field monitors, precision DME, and a remote control and status unit. When a back azimuth subsystem was used, it was considered to be identical to the Basic azimuth subsystem. A block diagram of the Basic MLS is shown in Figure 3-2.

3.1.3.3 Basic II MLS

The Basic II MLS was similar to the Basic MLS, except that all the electronics, transmitters, and power supplies were redundant, in hot standby, for operational availability considerations. The precision DME was also dual.

3.1.3.4 Expanded MLS

The Expanded MLS was similar to the Basic II, except that the azimuth antenna was 1° instead of 2°. The 1° azimuth antenna used 116 active elements with 2 dummy elements on either end, for a total of 120 elements. The 1° azimuth antenna was similar to the Basic wide azimuth at NASA Wallops Island. All electronics, transmitters, and power supplies were redundant, in hot standby, for operational availability considerations. The precision DME was also dual.

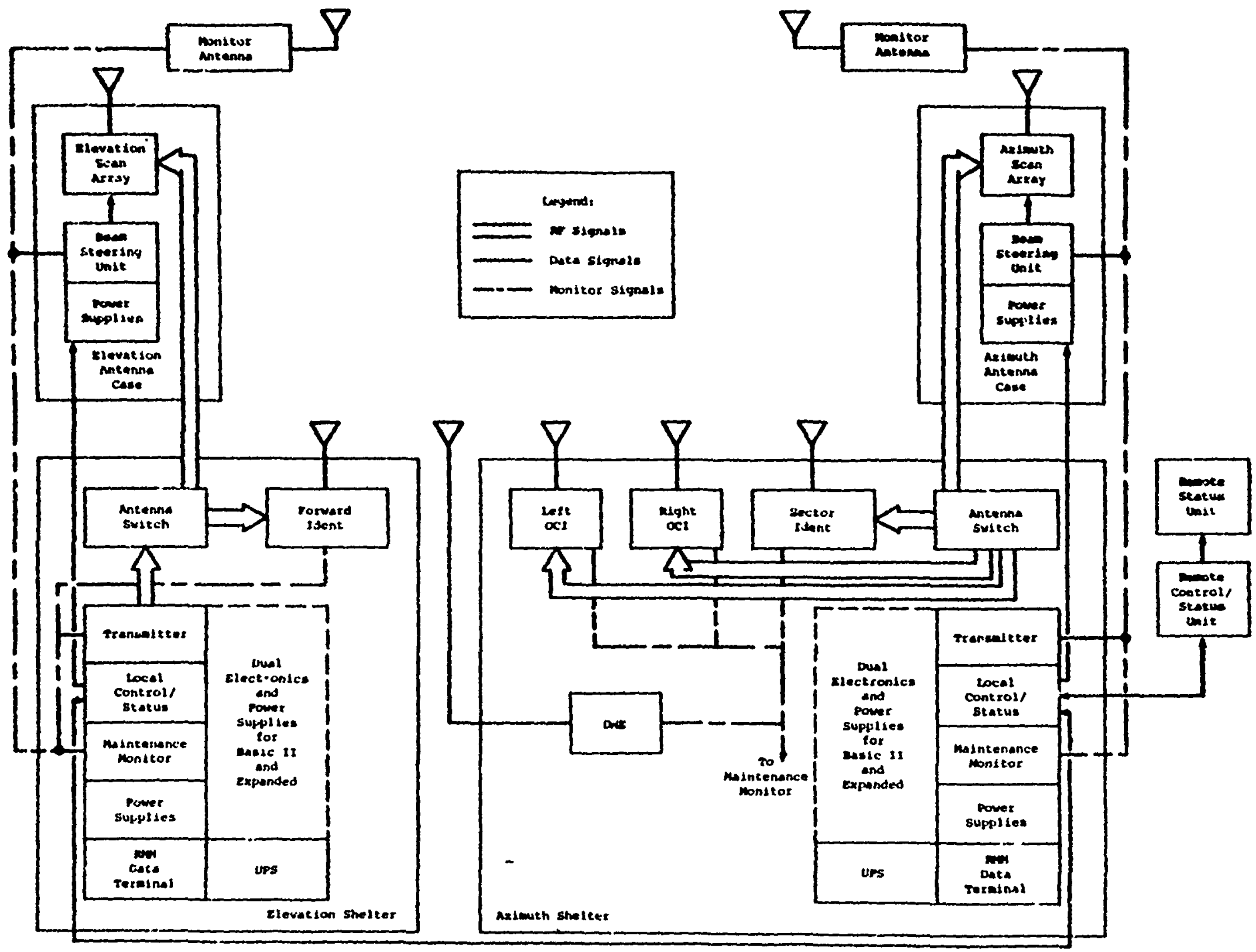

Figure 3-2. REPRESENTATIVE BLOCK DIAGRAM OF BASIC MLS CONFIGURATION

3.2 ACQUISITION COSTS

3.2.1 General

Unit acquisition costs of all ground MLS equipments were calculated using the parametric method of pricing, which estimates costs on the basis of various physical and economic descriptors of the equipment being evaluated. To ensure accuracy in the characterization of existing equipment, all modules or PCBs of specific subassemblies were measured and weighted. Where large structures such as antenna enclosures were involved, the structure was measured, and the weight was calculated on the basis of the material used in the structure. Where subassemblies such as power supplies, amplifiers, and air conditioners may be purchased, potential suppliers were contacted so that probable prices could be determined. These purchase prices were then entered into the pricing model.

On the basis of common experience, G&A was assumed to be 20 percent, profit 15 percent, and internal research and development (IR&D) 6 percent. When parts were to be purchased, a material handling cost of 10 percent was assumed.

Subassembly and system costs were developed in sufficient detail to identify the manufacturing costs associated with system development and production. We used PRICE complexity inputs associated with military specification quality parts.

Appendix A illustrates a typical PRICE input sheet and output printout and lists subassemblies and their associated development and manufacturing costs for Basic I and SCMLS for a 180-unit production run.

3.2.2 System Unit Costs

Unit acquisition costs were determined with PRICE for four MLS configurations -- SCMLS, Basic I, Basic II, and Expanded. The unit costs, shown in Tables 3-3 through 3-6 for variable production runs, reflect amortization of development costs over the entire production run. With the exception of antenna enclosures, system parts were assumed to be manufactured in sufficient quantities to allow for provisioning of spare parts. These additional manufactured parts allowed a slight decrease in the cost of manufactured parts because of the increased quantities produced.

3.2.2.1 Production Methods

The unit costs in Tables 3-3 through 3-6 are based on production quantities of 75, 110, 145, and 180 systems over a manufacturing period of three years. Variable production quantities were evaluated to investigate the sensitivity of system costs to production rates.

Table 3-3. MLS UNIT PRODUCTION COSTS FOR THREE-YEAR PRODUCTION RUN, 75 SYSTEMS				
Subsystem	Cost by System Type (Constant 1980 Dollars)			
	SCMLS (75 Systems)	Basic I (55 Systems)	Basic II (13 Systems)	Expanded (7 Systems)
Azimuth Antenna	70,800	65,600	74,800	171,200
Elevation Antenna	64,000	59,200	69,500	69,500
Azimuth Electronics	*	82,000	161,800	161,800
Elevation Electronics	**	84,500	166,800	166,800
Shelters	N/A	43,300	43,300	43,300
Field Monitors	6,100	6,100	6,100	6,100
Remote Maintenance Monitors	4,800	4,800	4,800	4,800
Remote Control and Status Panels	6,100	6,100	6,100	6,100
Integration and Test	6,500	13,600	14,300	15,000
Angle Equipment Cost	159,100	365,200	547,500	644,600
Distance-Measuring Equipment Cost	44,200	45,200	55,400	55,400
Total System Cost	203,300	410,400	602,900	700,000

*Costs are included in azimuth antenna costs.
**Costs are included in elevation antenna costs.

Although any manufacturer may apply a given design technique to the entire probable MLS matrix of azimuth and elevation beamwidth combinations, our analysis was intentionally structured to look at two different design techniques -- thinned array and full array. Since the SCMLS and Basic MLSs defined in this study use these two different design techniques, it was assumed that one manufacturer (or group of manufacturers) would provide SCMLS equipment and another would provide the Basic versions of MLS. Under this assumption, the number of SCMLS built during a production run would be equal to the entire production run. The number of each of the Basic versions manufactured during a production run was based on the final total percentage mix of Basic MLSs procured over the life cycle weighed against the implementation strategy. For example, for the 75-unit production run, we assumed 55 Basic I, 13 Basic II, and 7 Expanded systems over three years. This percentage system mix was employed for all production uses. Also included was adequate manufacturing to produce the required back azimuth systems.

3.2.2.2 Subsystem Costs

The following sections describe the various subsystems of the ground equipments.

Table 3-4. MLS UNIT PRODUCTION COSTS FOR THREE-YEAR PRODUCTION RUN, 110 SYSTEMS				
Subsystem	Cost by System Type (Constant 1980 Dollars)			
	SCMLS (110 Systems)	Basic I (81 Systems)	Basic II (19 Systems)	Expanded (10 Systems)
Azimuth Antenna	67,300	59,000	66,900	146,100
Elevation Antenna	61,500	51,900	61,000	61,000
Azimuth Electronics	*	78,700	155,800	155,800
Elevation Electronics	**	80,200	158,900	158,900
Shelters	N/A	42,200	42,200	42,200
Field Monitors	5,700	5,700	5,700	5,700
Remote Maintenance Monitors	4,900	4,900	4,900	4,900
Remote Control and Status Panels	5,300	5,300	5,300	5,300
Integration and Test	5,500	11,700	12,300	12,900
Angle Equipment Cost	150,200	339,600	513,000	592,800
Distance-Measuring Equipment Cost	44,200	45,200	55,400	55,400
Total System Cost	194,400	384,800	568,400	648,200

*Costs are included in azimuth antenna costs.
**Costs are included in elevation antenna costs.

Table 3-5. MLS UNIT PRODUCTION COSTS FOR THREE-YEAR PRODUCTION RUN, 145 SYSTEMS				
Subsystem	Cost by System Type (Constant 1980 Dollars)			
	SCMLS (145 Systems)	Basic I (106 Systems)	Basic II (25 Systems)	Expanded (14 Systems)
Azimuth Antenna	65,100	55,000	62,000	127,500
Elevation Antenna	59,500	49,300	57,800	57,800
Azimuth Electronics	*	77,000	152,400	152,400
Elevation Electronics	**	78,300	154,900	154,900
Shelters	N/A	41,500	41,500	41,500
Field Monitors	5,400	5,400	5,400	5,400
Remote Maintenance Monitors	4,900	4,900	4,900	4,900
Remote Control and Status Panels	4,900	4,900	4,900	4,900
Integration and Test	4,800	10,600	11,100	11,700
Angle Equipment Cost	144,600	326,900	494,900	561,000
Distance-Measuring Equipment Cost	44,200	45,200	55,400	55,400
Total System Cost	188,800	372,100	550,300	616,400

*Costs are included in azimuth antenna costs.
**Costs are included in elevation antenna costs.

Table 3-6. MLS UNIT PRODUCTION COSTS FOR THREE-YEAR PRODUCTION RUN, 180 SYSTEMS				
Subsystem	Cost by System Type (Constant 1980 Dollars)			
	SCMLS (180 Systems)	Basic I (132 Systems)	Basic II (31 Systems)	Expanded (17 Systems)
Azimuth Antenna	63,500	52,400	58,200	115,600
Elevation Antenna	58,100	46,500	54,600	54,600
Azimuth Electronics	*	75,700	149,800	149,800
Elevation Electronics	**	76,900	152,200	152,200
Shelters	N/A	40,900	40,900	40,900
Field Monitors	5,200	5,200	5,200	5,200
Remote Maintenance Monitors	4,900	4,900	4,900	4,900
Remote Control and Status Panels	4,600	4,600	4,600	4,600
Integration and Test	4,400	9,500	10,000	10,500
Angle Equipment Cost	140,700	316,600	480,400	538,300
Distance-Measuring Equipment Cost	44,200	45,200	55,400	55,400
Total System Cost	184,900	361,800	535,800	593,700

*Costs are included in azimuth antenna costs.
**Costs are included in elevation antenna costs.

Azimuth Antenna

Because all the electronics, transmitters, and power supplies were included in the antenna enclosure, azimuth antenna costs for the SCMLS included not only the antenna array, enclosure, and radome, but the cost of the total azimuth subsystem. Azimuth antenna costs for the Basic versions of MLS included only the cost of the actual antenna subsystem -- in this case, the costs of the antenna array, enclosure, radome, and any electronics and power supplies particularly included in the antenna enclosure. Additional costs associated with the Basic II configuration were the result of redundant components. The Expanded configuration had redundant components as well as a larger antenna and array.

Elevation Antenna

Elevation antenna costs for the SCMLS and Basic configurations were structured similar to azimuth antenna costs. Additional costs for the Basic II and Expanded configurations were the result of redundant components.

Azimuth Electronics

SCMLS electronics costs were included in the azimuth antenna costs. The additional Basic azimuth electronics costs represented the maintenance monitor cards, local control cards, electronics and maintenance power supplies, transmitters, card chassis, electronics cabinet, and other electronic components separate from the antenna enclosure. Additional costs for the Basic II and Expanded configurations were the result of redundant components.

Elevation Electronics

Elevation electronics costs for the SCMLS and Basic configurations were structured similar to azimuth electronics costs.

Shelters

There were no shelter costs for the SCMLS, because the electronics were housed in the antenna enclosure. The weatherproof maintenance shelter was included in the antenna subsystem cost.

Shelter costs shown in the tables represent the total cost for the two shelters required for the azimuth and elevation subsystem electronics. The shelters priced were 8 feet by 8 feet by 12 feet. The costs included the environmental conditioning requirements, work benches, and junction boxes expected to be associated with MLS shelters. The azimuth shelter cost approximately $3,000 more than the elevation shelter because of the required auxiliary antennas.

Field Monitors

The field monitors priced were independent monitors for the azimuth and elevation antenna sites and were similar to existing mast-type field monitors used with the prototype Basic wide MLS. The same monitor type and hence the same cost was used for both the SCMLS and Basic MLSs.

Remote Maintenance Monitors

The remote maintenance monitor (RMM) was considered to be a microcomputer capable of collecting, storing, analyzing, and transmitting any monitor data to a maintenance facility as required. Included in the RMM line was a modem for transmitting and receiving data. An RMM was included with each azimuth and elevation subsystem; similar RMMs were used for SCMLS and Basic MLSs.

Remote Control and Status Panels

The remote control and status panels consisted of a remote control and status unit (RCSU) located in the tower or maintenance facility and a remote status panel installed at an off-site facility. The remote status panel was considered to be a simple device providing alarms and status indications of each equipment. The RCSU was a much more complex unit having not only status indications, but also subsystem-control capability. It consisted of two power supplies, three PCBs, and the associated chassis and connections.

We assumed that similar units would be provided for both SCMLS and Basic MLSs.

Integration and Test

The costs of integration and test shown in the tables reflect the costs associated with integrating the subsystems into one complete MLS. This cost, which is applied after all other parts have been manufactured or purchased and subassembled, is associated with normal manufacturing practices and does not take into account any extra-intensive testing that may be associated with initial implementation of the MLS. Integration and test costs associated with assembling the various subsystems were included in the subsystem cost element.

Distance-Measuring Equipment

Since DME equipment or costs were not specifically evaluated, DME costs are listed in the tables as a separate line-item cost. In addition, DME for the SCMLS may be a contract option, depending on the desired SCMLS installation. A DME cost was included in all of our SCMLS installations for the LCC analysis.

The DME costs listed in Tables 3-3 through 3-6 were based on the unit DME costs associated with single and dual DME equipments purchased by the FAA in 1977. Those costs were inflated to 1980 dollars. We assumed that an MLS manufacturer would purchase rather than manufacture a DME for the MLS; accordingly, appropriate manufacturing markups associated with all purchased MLS materials were added to the baseline DME cost to determine a baseline DME equipment price. An additional cost that may be expected for integrating the DME with the MLS angle equipment was then added. For the Basic versions, $2,500 was included as a test and integration cost, because the DME could be installed in a cabinet inside the shelters where adequate space would exist. A $10,000 cost was added to the SCMLS DME price of $34,200 to reflect shelterizing the DME, because DME costs were not investigated during this analysis, nor was an analysis performed to increase the SCMLS enclosure size to include an integral DME. The $10,000 cost should be adequate to reflect either an integral DME included in the azimuth SCMLS enclosure or an independent DME.

Constant DME costs were used throughout the production runs, because the DMEs were treated as purchased items. We assumed that sufficient quantities of equipment would be purchased for the 75-unit production run to achieve the same price discounts that would be achievable with the 180-unit production run.

Back Azimuth Equipment

Back azimuth equipment was not priced separately for unit acquisition costs; however, it was included in the LCC analysis. Back azimuth equipment, where used, was considered to be composed of the elements required in an azimuth subsystem.

3.2.2.3 Production Quantity Costs

The PRICE parametric cost model determines the development and manufacturing costs for the equipment under analysis. The development cost is constant for any quantity of equipment; the manufacturing cost is adjusted to allow for the learning curve cost effect expected in larger quantity procurements. The overall result is lower production costs associated with larger quantity procurements, because the lower manufacturing costs and the development costs are amortized over a larger number of equipment. The product improvement factors input to PRICE resulted in a learning curve of approximately 92 percent. Costs of purchased items did not change significantly with large production quantities, because they had been determined on the basis of quantities of 100 or more.

For the purpose of this analysis, it was assumed that multiyear contracts of three years would be let to allow new technology to be incorporated into the MLSs every three years if desired and to allow for new manufacturers entering the market. Both of these possibilities permitted the use of a constant unit acquisition cost throughout the LCC study on the basis of the premise that new technology or new manufacturers will cause continual recurring costs, which will be amortized over any production run.

Tables 3-7 and 3-8 illustrate the development and manufacturing costs associated with the SCMLS and Basic MLS configurations. Neither table reflects a cost that may be associated with development of a design concept.

Table 3-7. SCMLS DEVELOPMENT AND MANUFACTURING COSTS FOR THREE-YEAR PRODUCTION RUN

Subsystem	Development Cost	Quantity Manufacturing Costs (Millions of Constant 1980 Dollars)			
		75 Systems	110 Systems	145 Systems	180 Systems
Elevation Antenna	0.378	1.691	2.422	3.024	3.655
Azimuth Antenna	0.384	2.440	3.478	4.643	5.223
Electronics	0.441	5.914	8.602	11.239	13.841
Field Monitors	0.046	0.390	0.602	0.765	0.925
Remote Maintenance Monitors	0.003	0.377	0.560	0.741	0.923
Remote Control and Status Panels	0.133	0.356	0.494	0.628	0.759
Integration and Test	0.159	0.344	0.470	0.560	0.660
Total	1.544	11.512	16.628	21.600	25.986
Total Angle Equipment Production Cost (Development plus Manufacturing)		13.056	18.172	23.144	27.530
Distance-Measuring Equipment Cost		3.315	4.862	6.409	7.956
Total System Cost		16.371	23.034	29.553	35.486

Table 3-8. **BASIC DEVELOPMENT AND MANUFACTURING COSTS FOR THREE-YEAR PRODUCTION RUN**					
Subsystem	**Development Cost**	**Quantity Manufacturing Costs (Millions of Constant 1980 Dollars)**			
		75 Systems	110 Systems	145 Systems	180 Systems
Elevation Antenna	0.916	4.501	6.210	7.893	9.114
Azimuth Antenna	0.924	5.346	7.446	9.369	10.875
Azimuth Expanded Antenna	0.416	0.232	0.306	0.402	0.471
Electronics	1.250	14.630	20.080	28.390	36.150
Shelters	0.102	3.212	4.684	6.120	7.516
Field Monitors	0.046	0.438	0.612	0.781	0.978
Remote Maintenance Monitors	0.003	0.387	0.571	0.752	0.936
Remote Control and Status Panels	0.133	0.356	0.494	0.628	0.759
Integration and Test	0.262	0.826	1.116	1.384	1.571
Total	4.052	29.928	41.519	55.719	68.370
Total Angle Equipment Production Cost (Development plus Manufacturing)		33.980	45.571	59.771	72.422
Distance-Measuring Equipment Cost		3.594	5.268	6.952	8.626
Total System Cost		37.574	50.839	66.723	81.048

PRICE identifies development costs associated with design, engineering, management, and prototype tooling and equipment production, not concept development.

The manufacturing cost represents the cost of producing the required number of systems and includes parts manufactured and parts purchased for the system. The manufacturing costs take into account the number of back azimuth systems required to satisfy the assumption of 10 percent SCMLS and 20 percent Basic I. The Basic systems were apportioned between Basic I, Basic II, and Expanded configurations, as illustrated in Tables 3-3 through 3-6.

Development costs associated with the Basic configurations are approximately 2.4 times those of the SCMLS antenna costs and 2.8 times those of the SCMLS electronics. The overall Basic development costs reflect the costs associated with developing a 1° azimuth configuration and developing a sheltered configuration. Similar development and manufacturing costs were assumed for the field monitors, RMMs, and RCSUs for the SCMLS and Basic configurations.

Figure 3-3 illustrates the downward trend in SCMLS unit system costs, even as total production costs rise with increased systems produced. Production costs include back azimuth systems and development costs. DME costs

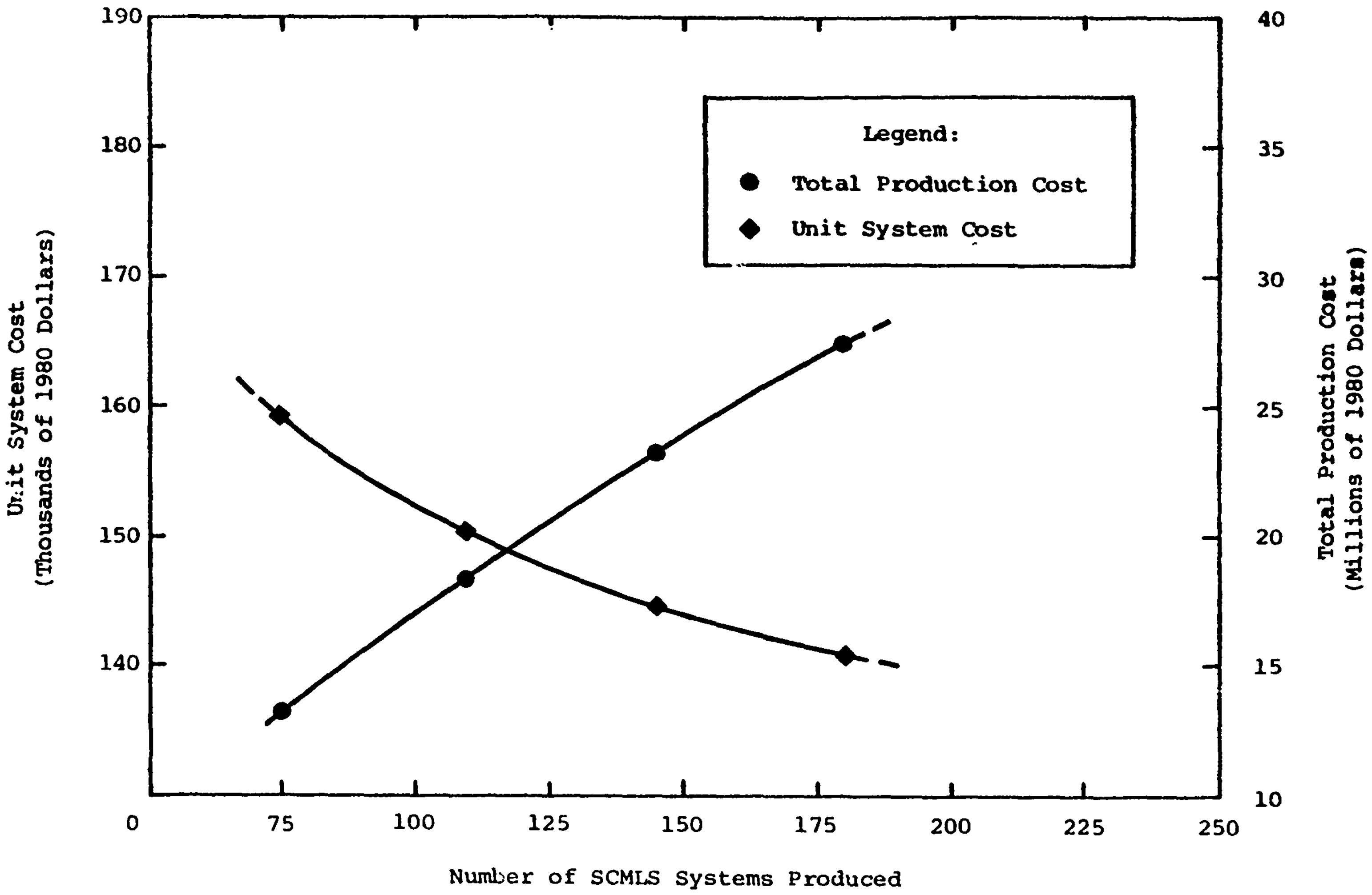

Figure 3-3. SCMLS UNIT AND TOTAL PRODUCTION COSTS (DME COSTS NOT INCLUDED)

are not included in Figure 3-3. A similar figure is not provided for the Basic configuration because of the mix of systems (Basic I, Basic II, and Expanded) involved in any given production quantity. The system cost associated with any Basic configuration would be reduced, because the total parts would be manufactured for all three configurations.

CHAPTER FOUR

GROUND LIFE-CYCLE-COST MODEL COMMON PARAMETERS

This chapter addresses the development of the data items that were treated in the economic analysis as being common to any MLS configuration or pertinent to the total system implementation. These items included the estimated installation costs of each configuration, the implementation plan, and the maintenance scenario used in the life-cycle-cost analysis.

4.1 INSTALLATION COSTS

Installation costs for ground equipment fell under such categories as site preparation and construction, actual equipment installation and check-out, and flight check and certification. Rather than viewing MLS installations in these categories, we chose to evaluate the total installation cost in terms of personnel, equipment, and material costs required, as well as trenching and flight inspection costs. Documents used to develop the rationale for these costs were NASA Technical Memorandum 78588 of August 1979, *Site Preparation and Installation of the Prototype Texas Instruments Basic Narrow Configuration Microwave Landing System;* FAA Handbook 6750.16A, *Siting Criteria for Instrument Landing Systems;* FAA Specification FAA-E-2492 for Turnkey ILS; and FAA Order 6750.22, *National ILS Establishment Contracts* -- as well as Bendix documents pertaining to the Basic wide MLS installation at NASA Wallops Island, and Hazeltine drawings for SCMLS installations.

Table 4-1 illustrates the expected MLS installation costs for each type of system. The costs were developed around a concept of the SCMLS being installed on a 6,900-foot runway, Basic on a 9,800-foot runway, and Expanded on a 15,900-foot runway. These runway lengths are approximate average distances, taken from the MLS TDP. The complete development of installation costs is explained in Appendix B. All costs were based on a split-site configuration.

Personnel costs shown in Table 4-1 represent the costs of FAA regional personnel, MLS contractor personnel, and subcontractor personnel actually involved in constructing the site. Equipment costs include the costs for equipment such as trucks, graders, excavators, and cranes actually used in constructing the site, as well as $1,800 assumed for preflight inspection flights. Material costs include costs associated with concrete, reinforcing rods, anchor bolts, and so forth. Cable material costs and the labor required to lay the cable are included in the trenching costs.

Table 4-1. MICROWAVE LANDING SYSTEM INSTALLATION COSTS

Cost Category	Cost by System Type (1980 Dollars)		
	SCMLS	Basic	Expanded
Personnel	48,000	65,900	84,000
Equipment	8,500	9,400	9,400
Material	8,000	13,000	13,000
Intersite Trenching	38,300	64,900	97,200
Cable to Remote Control/Status	26,500	26,500	26,500
Roads and Power	23,400	23,400	23,400
Total Nominal Site Cost	152,700	203,100	253,500
Total Difficult Site Cost*	305,400	406,200	507,000
Weighted Average Site Cost**	167,970	223,410	278,850
Flight Inspection Cost	25,320	37,020	48,720
Total Cost†	193,300	260,400	327,600

*One hundred percent increase over nominal site cost.
**Ninety percent nominal site cost plus 10 percent difficult site cost.
†Rounded to nearest $100.

The total nominal site cost is an accumulation of all costs associated with site preparation, construction, equipment installation, and initial on-site certification. This is an average cost developed through Means Building Construction Cost Data, which are widely used by the construction industry and the FAA for estimating costs. Costs can easily vary by geographic location and site geological composition. Nominal site costs do not include any tunneling under runways. With a nominal tunneling cost of $245 per foot, an additional $25,000 to $40,000 (depending on runway width) could quickly be added to any site requiring tunneling. To compensate for some of these expected variations, we established a total difficult site cost with a 100 percent increase over the nominal cost. This assumption may be compared to FAA Report EM-80-7, which shows that difficult sites could easily exceed nominal costs by 130 to 150 percent. We developed a weighted average site cost by assuming that 10 percent of the installations would be difficult. We used the 10 percent assumption rather than the 25 percent assumption used in the cost benefits analysis, because there are no assumptions made that construction at some sites may be easier than normal. For these sites, according to Means Construction data, the cost may be expected to be 25 to 35 percent less than average. In addition, runway lengths may be less than the maximum lengths assumed for each type of system.

Flight inspection costs were added to the weighted average site cost to determine a total cost for MLS installation. Flight hour costs are the airways facilities-projected 1980 composite flight inspection rate. The costs shown in Table 4-1 were used in the LCC analysis.

Sites involving a back azimuth system for the SCMLS or Basic configuration were assumed to incur an additional cost for this installation. We assumed that there would be an additional 2,000 feet of trenching from the evaluation site to the back azimuth site for SCMLS or Basic. The additional costs would be for the trenching to monitors and the concrete pads. It was assumed that the back azimuth installation would be the same as the front azimuth sites for both configurations. No additional personnel or equipment costs were assumed for back azimuth sites. The installation cost associated with the Basic back azimuth configuration was $5,200 for material and $19,900 for intersite trenching, for a total of $25,100. The SCMLS back azimuth installation cost was $2,500 for material and $11,300 for intersite trenching, for a total of $13,800.

The costs shown in Table 4-1 are those that relate only to MLS installation. We did not assume any cost advantages that may be available because of existing ILS facilities.

4.2 MLS IMPLEMENTATION

A major factor in the LCC analysis was the implementation schedule for the MLS. The implementation schedule drives the production quantities per year and the operations and maintenance costs per year and cumulatively. The following factors were addressed in determining an implementation schedule:

- Type of MLS to be installed -- Basic or SCMLS
- Category of service (I, II, or III)
- Year of installation
- Type of airport to be equipped with MLS

In the *Draft Microwave Landing System Transition Plan* of 20 October 1980, the FAA identified and examined 10 possible strategies for developing the MLS. A computer model was developed to evaluate each strategy with respect to operational and economic considerations. The model used the following basic types of data:

- Implementation strategy
- Numerical parameters
    - •• User class benefits

- •• Ground and airborne system LCCs
- •• MLS establishment criteria
- •• Avionics equipage trends
- •• Factors used in apportioning annual instrument approaches (AIAs)

Using the model as an evaluation tool, the FAA determined that there was no statistically significant economic rationale for choosing between implementation strategies. Therefore, the draft transition plan pointed out that the "choice between strategies must depend upon operational considerations or on the special opportunities for improved precision guidance service created by the installation of MLS equipment." Since a final transition strategy had not yet been decided, it was necessary to pick one for the LCC because of the time constraints of the study.

Implementation strategy 9 was selected, because it was the preferred strategy in the *Draft Precision Approach System Transition Plan* of 7 June 1979. In that plan, strategy 9 was considered to be superior with regard to schedule and operational considerations. Although this strategy was implemented in the LCC study, the economic analysis model was structured with adequate flexibility to allow any implementation strategy to be used.

Both draft transition plans offer the planned system distribution by the year 2005, as shown in Table 4-2. The Category I systems are not specifically divided between SCMLS and Basic systems, although both transition plans provide for the installation of the SCMLS on a majority of the runways at nonhub and general aviation airports that qualify for a Category I system. For this analysis, it was assumed that 50 percent of the Category I systems were SCMLS.

Table 4-2. DISTRIBUTION OF MLS BY YEAR 2005

Airport Type	Expected Number of Systems by Category			Total
	I (SCMLS/Basic)	II (Basic)	III (Expanded)	
Large Hub	170	37	47	254
Medium Hub	108	31	15	154
Small Hub	224	94	0	318
Nonhub	307	26	0	333
General Aviation	118	0	0	118
Total	927	188	62	1,177

Using the airport MLS distribution data presented in the June 1979 draft transition plan, and linearly interpolating between years, we developed the implementation schedule for the MLSs used for this LCC analysis. Table 4-3 presents the implementation schedule and shows the additional azimuth systems required to satisfy the requirements for back azimuth at 20 percent of the Basic MLS sites and 10 percent of the SCMLS locations.

In using the implementation schedule in the EAM, we assumed that systems would be acquired beginning in 1985 and deployed two years after acquisition. Because of the dependency of the life-cycle cost on the implementation plan, the EAM was designed with a flexibility to investigate other implementation strategies. These other implementation plans are discussed in Chapter Six.

4.3 MAINTENANCE SCENARIO

For the purpose of this study, it was assumed that the centralized maintenance concept would be used for all ground system maintenance. All skill levels, labor rates, productivity, and travel times were determined on this basis. RMM equipment was included in all ground systems. To implement the RMM centralized maintenance concept for the MLS, we updated the findings of ARINC Research's June 1978 *Quick-Look Analysis of Key Factors Associated With the Federal Aviation Administration Airways Facilities Remote Maintenance Monitoring System Concept*.

The maintenance scenario used in the life-cycle-cost model (LCCM) considered two levels of repair -- on-site and off-site maintenance. On-site maintenance consists of removal and replacement of failed modules or their component parts (submodules), actual repair of a small fraction of these failures at the system site, and preventive maintenance actions. Off-site maintenance encompasses all other maintenance activities associated with a system failure.

It was assumed that throughout the life cycle of the MLS ground system there would be 75 base repair facilities, as stated in the MLS LCC program plan. While this parameter could be varied in a sensitivity analysis to determine the effect of a greater or lesser number of repair stations on the costs of system maintenance, that effort was not included in the scope of this study.

Using the centralized maintenance concept, we assumed the following four levels of module repair:

- Discard and replace (for units whose replacement costs are less than repair costs)
- On site (for units that cannot be reasonably transported)
- Central repair group at the hub (for units that can be repaired with sector diagnostics and repair tools)
- Depot (for units requiring special diagnostics and repair tools)

Table 4-3. NUMBER OF MLS GROUND SYSTEMS ACQUIRED FROM 1985 TO 2004

System	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Expanded	0	5	4	5	4	5	0	0	0	0	0	4	4	4	4	4	4	5	5	5	62
Basic II	0	8	8	8	7	8	0	0	0	0	0	16	16	16	16	16	17	17	18	17	188
Basic I	5	33	31	32	30	33	24	26	25	25	26	20	18	21	18	18	20	19	19	21	464
SCMLS	87	14	14	14	14	15	24	25	24	26	26	19	20	19	22	20	21	21	20	18	463
Additional Azimuth Systems to be Acquired for Back Azimuth																					
Basic I	1	6	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	4	4	4	92
SCMLS	9	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	46

4.3.1 On-Site Maintenance

The scenario used in calculating on-site maintenance costs and personnel requirements was adapted from ARINC Research Corporation's Facility Maintenance Cost Model, described in AAF Report 220-78-01, Volumes I and III. On-site maintenance actions include preventive maintenance (PM) and corrective maintenance (CM) activities. The number of repair personnel required was calculated on the basis of the expected PM and CM demand for the system under evaluation.

PM cost is determined by the maintenance man-hours required to perform the PM functions applicable to the system under evaluation, as well as the travel time and mileage to the site. Three maintenance man-hours per PM visit were assumed to be sufficient to allow completion of all required PM actions, given a rate of two PM visits per site per year. Travel time and mileage were computed using the assumption of a homogeneous distribution of system sites and repair facilities throughout the continental United States (i.e., each repair facility was given maintenance responsibility for the same number of system sites), an average travel speed of 35 mph, and a travel cost of 21¢ per mile. These and other assumptions affecting the maintenance scenario are shown in Figure 4-1.

CM actions are those initiated by a system failure and consist of removal and replacement actions and a small amount of on-site repair for items such as the antenna enclosure. The failure may be castastrophic, caused by a component failure, or it may be caused by performance degradation below the tolerances specified for site operation. Either type of failure would normally require replacement of modules, submodules, or entire systems, depending on the severity of the failure.

The remote maintenance monitoring system concept used in developing the LCCM provides systems at the central facilities (bases) for monitoring the remote system site performance. The LCCM assumes that all failures are scheduled for immediate repair when the need for corrective maintenance is established and reported to the responsible hub by the RMM.

CM costs include those for travel time from the technician's normal duty station to the failed unit site, test and diagnostic setup time, fault-isolation time, time to remove and replace or repair, operational test time, travel time back to the technician's normal duty station, and mileage to and from the failed system site. CM travel time and mileage were computed using the assumptions described for preventive maintenance.

For this evaluation, test and diagnostic setup time, fault-isolation time, and operational test time were represented by a single variable. The value assigned to this variable was determined on the basis of three important assumptions. First, the RMM concept was defined to have the ability to report not only the event of a system failure, but the components that most likely caused the failure, thus reducing the amount of time required at the site to fault-isolate and test. In most cases the technician would simply obtain the necessary replacement parts from inventory and carry them

There are 75 remote maintenance monitor (RMM) computer sites (hubs).

There are three depot repair facilities.

The area of the continental United States is 3×10^6 square miles.

The average travel speed is 35 mph.

The cost of travel is 21¢ per mile.

The average facility repair time at a remote site for equipment too large to be taken to a hub is 16 man-hours.

Ninety-five percent of the equipment taken to a hub for repair is repaired at the hub; the remaining five percent is repaired at a depot.

The average equipment repair time at a hub or depot is three hours per item.

The turnaround time for equipment repaired at a hub is 5 days; the turnaround time for equipment repaired at a depot is 60 days.

The following labor rates were assumed:

Journeyman technician - $30,329 per annum

Base-level repairman - $36,234 per annum

Depot-level repairman - $42,907 per annum

A facility will be visited twice a year.

A minimum staff of five people plus one floater (providing coverage of 24 hours a day, 365 days a year) will be assigned to each maintenance office.

Maintenance manpower will be computed to yield a probability of 0.84 that a technician will be available when required.

Spare quantities will be computed to yield a probability of 0.50 that a spare will be available when required.

Figure 4-1. BASELINE CASE ASSUMPTIONS

to the site. However, because the model assumes only one person per CM action, and many system failures may require the presence of more than one repair technician (e.g., a power supply failure), the time required to effect repair at the site would be increased. The assumption of more than one person per CM action would be applicable to the times required to remove and replace or repair failed components as well.

4.3.2 Off-Site Maintenance

Off-site maintenance costs are costs incurred when a failed component is not repaired at the system site but is brought to the hub, or base, for repair. These expenses include the costs of materials, labor, shipping, and failure documentation. For this analysis, it was assumed that modules are always repaired at the site by replacement of submodules, and that submodules are normally repaired at the base or depot. It was also assumed that the equipment manufacturer would provide the required depot support.

Ninety-five percent of all off-site repairs were assumed to be performed at the base level with the remaining five percent performed at the depot. Repair times attributed to each module and submodule allow for the time required to document a failure and the corresponding repair action in addition to the actual time required for repair. If the failed component is determined to be nonrepairable, either because it has been too severely damaged or it is a "throw-away" item, it is simply discarded and replaced with a new component. Otherwise, the failed item is assessed and then repaired at the base or depot, depending on the complexity of repair required.

If the necessary repair action is beyond the capability of the base repair personnel, the submodule is packaged and shipped to the depot for repair. Because of the number of systems procured over the lifetime of the system implementation, three depots were presumed for this analysis to allow for a competitive posture while ensuring adequate production quantities per manufacturer.

Once the failed unit arrives at the depot, it is repaired, incurring labor and materials costs peculiar to the particular submodule under repair. The maintenance action performed is documented, and the repaired item is shipped back to the base, thus completing the maintenance cycle.

It was assumed that a pipeline time (turnaround time) of 60 days would be assigned to those items returned to the depot for repair, while a five-day pipeline time would be assigned to items repaired at the base level. These pipeline times, along with the base and depot stocking objectives and order and shipping times for modules and submodules, would affect the number of spares of each type held in inventory at the base and depot levels. A shorter pipeline time at either the base or depot would result in fewer spares being held in inventory; thus a tradeoff would exist between the amount of time allotted for module and submodule turnaround and the number of spares in inventory. A decrease in the turnaround time would result in a decrease in spares inventory and thus a lower cost. Conversely, an increase in turnaround time would result in an increase in spares inventory and a corresponding increase in cost.

4.3.3 Maintenance Actions

Maintenance actions required by the model are based on the serial reliability of each subassembly making up the total system rather than on the system operational availability. Each subassembly, from the electronics to the waveguide elements, has an assigned MTBF as determined by PRICE or GIFRDE data. This means that the sparing and maintenance actions calculated by the LCC model included spares and maintenance actions for antenna chassis, radomes, and shelters, as well as the active electronics. Typical MTBF values are shown in Appendix A.

CHAPTER FIVE

INDIVIDUAL AND SYSTEM COSTS FOR MLS GROUND SYSTEM IMPLEMENTATION

5.1 COST MODEL

To evaluate the LCC of the ground MLS equipment, ARINC Research Corporation adapted and updated its economic analysis model by incorporating the Facility Maintenance Cost Model developed under Contract DOT-TSC-1173-2 into the EAM. This allowed increased analysis of costs peculiar to the centralized maintenance concept.

The model has been programmed in FORTRAN IV+ for use with a Digital Equipment Corporation PDP-11/34 minicomputer. It computes the expected annual and cumulative acquisition, installation, and logistic support costs for each concept. The program is flexible to accommodate data changes, sensitivity evaluations, or additional data outputs. Appendix D documents the program features and mathematical formulation of the EAM; Appendix E is a program listing of the EAM.

5.2 ADDITIONAL INPUTS REQUIRED BY THE MODEL

The data developed in Chapters Three and Four constitute only a portion of the data required to compare systems or establish the cost of implementation. All the data necessary to establish the cost of implementing the MLS were developed through research conducted by ARINC Research Corporation for this contract and others. A complete list of the parameters influencing the LCC evaluation is tabulated in Appendix F. All the parameters considered to be influential when evaluating the relative costs and reliability of the system have been programmed into the cost model.

5.3 RESULTS OF APPLYING THE ECONOMIC ANALYSIS MODEL

The ARINC Research EAM computed annual and cumulative acquisition, installation, and logistic support costs for each MLS configuration and deployment concept as well as for the total system implementation. The model was programmed to print out data for three additional years beyond the assumed installation period of 1987 through 2006 to aid in evaluating the effects of maintenance and logistics costs after system implementation.

This chapter presents the results derived from the model on the basis of the parametric inputs provided for the different MLS configurations. Acquisition, installation, and recurring logistic support costs are identified separately for each system type. Because of the quantity of data generated with six MLS configurations and four production quantities, most of the data are presented in summary form for one production quantity or one MLS configuration. The data presented were selected as being representative of any of the cost trends that might be expected with any production quantity. Complete LCC data for the six configurations are contained in Appendix C for a 180-system production run.

Each system costed was unique in its configuration, and the configuration was chosen for a particular utility. Accordingly, the systems were not compared with each other in terms of cost.

5.3.1 Life-Cycle Cost

Life-cycle cost -- the cumulative cost of system implementation (including the total costs of acquisition, installation, and nonrecurring and recurring logistic support) -- offers the best insight into the total cost of implementing the MLS.

Elements of the life-cycle cost are summarized in Tables 5-1 and 5-2 for a 75-system production run and a 180-system production run, respectively. These are the two extremes of the unit acquisition cost analysis. The tables include the initial investment costs (acquisition, installation, and nonrecurring logistics) and the continuing operations and maintenance cost (recurring logistics). The total system cost is based on a 25-year life-cycle analysis. A life cycle of 25 years was used in order to project the recurring logistics cost trends on the total life cycle independent of the investment cost impacts.

The cost-model outputs of Tables 5-1 and 5-2 are based on the data developed in Chapters Three and Four. A 3 percent factory inspection cost for all systems is included, in accordance with FAA practices. The outputs are in constant 1980 dollars (zero inflation rate) to permit comparison of costs with those of any other life-cycle study of comparable length, regardless of the start of implementation, providing that the base costs are presented in 1980 dollars. Discounted costs are presented in Section 5.4.

A comparison of Tables 5-1 and 5-2 illustrates the expected decrease in costs associated with increased manufacturing quantities. The largest decrease is in the acquisition cost of the total systems. The acquisition cost of $420.352 million for 180 systems is approximately 11.4 percent less than that for the 75-system production run when compared over the entire LCC. Both the nonrecurring and recurring logistics total LCCs for the 180-system production run are only about 6.7 percent less than those for the 75-system production run because of the number of cost elements in those cost categories which are independent of production quantity. These cost elements include all data elements such as inventory management, training, and

Table 5-1. LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 75 SCMLS OR 75 BASIC SYSTEMS

Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	96.931	3.618	196.129	16.348	116.753	44.698	474.477
Installation	89.498	0.635	120.826	2.309	48.956	20.311	282.535
Nonrecurring Logistics	25.608	2.600	24.533	3.145	22.251	21.127	99.264
Recurring Logistics	88.364	5.607	158.518	19.145	81.229	49.208	402.071
Total	300.401	12.460	500.006	40.947	269.189	135.344	1,258.347

Table 5-2. LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS OR 180 BASIC SYSTEMS (MILLIONS OF CONSTANT 1980 DOLLARS)

Cost Category	Cost by System Type						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	88.149	3.229	172.930	14.379	103.754	37.911	420.352
Installation	89.498	0.635	120.826	2.309	48.956	20.311	282.535
Nonrecurring Logistics	24.704	2.386	22.977	2.850	20.908	18.726	92.551
Recurring Logistics	84.020	5.191	148.263	15.845	75.336	43.720	372.375
Total	286.371	11.441	464.996	35.383	248.954	120.668	1,167.813

data management other than spares. Installation costs do not change with production quantity, because those costs are site-dependent and hardware-independent for system configurations having an assumed average installation cost. The overall effect of the production quantity price reduction is a reduction of approximately 7 percent in the total life-cycle cost -- from $1,258 million for the 75-system production quantity to $1,168 million for the 180-system production quantity.

The 180-system production run was selected to determine cumulative LCCs year by year. Figure 5-1 illustrates the LCC trends on a yearly basis. As is the case with all tables and figures in this chapter, Figure 5-1 is applicable only to the implementation strategy chosen; it more clearly reflects the impact of each cost category on the overall LCC. Acquisition costs were assumed to start at the beginning of the life-cycle period with the purchase of the first systems and stop after 20 years, which was the assumed acquisition period. Installation costs would start with the deployment of the first systems, which was assumed to begin two years after acquisition and run for 20 years. Recurring and nonrecurring logistics costs have been combined to project the total logistic support costs. These costs were also assumed to begin in the second year following acquisition and continue through the life of the system. Figure 5-1 also shows that the acquisition period is complete after 20 years, and that the installation of all systems will have occurred within 22 years after program initiation.

Figure 5-1 reflects the total system implementation; a single-system configuration implementation is illustrated in Figure 5-2 for the Basic I system and in Figure 5-3 for the SCMLS configuration. These figures are similar to Figure 5-1 in the general trend of the curves and are considered to be representative of the various configurations. All three figures show acquisition costs to be a dominating factor in the life cycle. Logistics costs will continue to accrue once the system is in place. Figure 5-3 illustrates the close relationship between the acquisition, installation, and logistics costs for the SCMLS configuration.

5.3.2 Logistic Support Costs

Logistic support (operations and maintenance costs) is the most complex of the cost categories. Acquisition and installation costs are dependent on the number of systems bought and deployed. Logistic support costs, on the other hand, are dependent on the cost of each subassembly of the total system, the implementation schedule, and the expected failure rates and costs of repair. Also included in logistic support costs are the costs of documentation and training associated with the new system.

Figure 5-4 illustrates the total logistic support cost taken from Figure 5-1, as well as its two component parts -- nonrecurring and recurring logistic support costs. Table 5-3 presents the nonrecurring and recurring logistic support costs by cost element. The data management cost associated with the SCMLS is larger than that for any Basic configuration because of the uniqueness of the SCMLS and the commonality among the Basic configurations. The EAM used commonality among systems as a factor to reduce costs incurred.

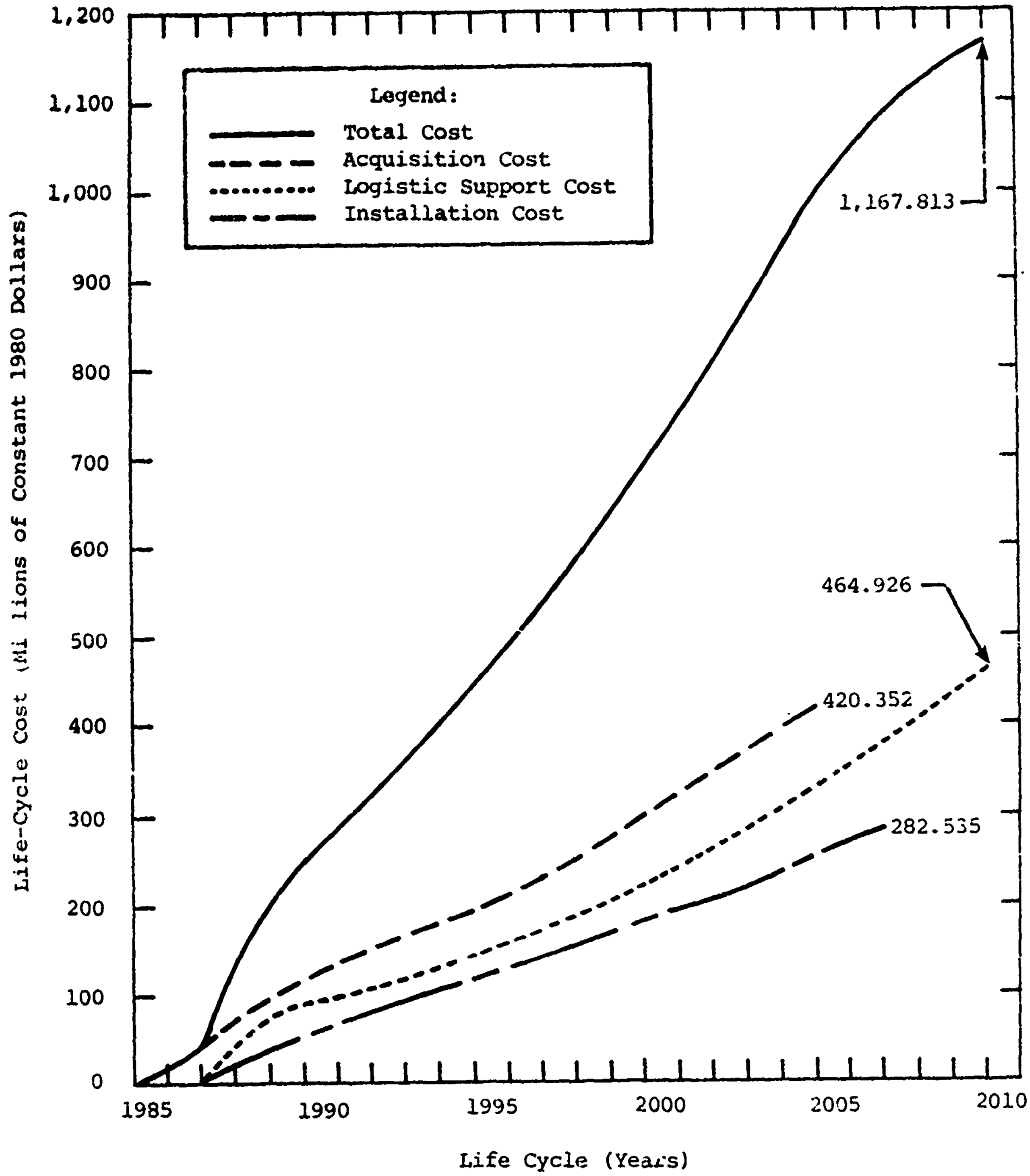

Figure 5-1. CUMULATIVE LIFE-CYCLE COST -- TOTAL SYSTEM IMPLEMENTATION, 180-SYSTEM PRODUCTION QUANTITY

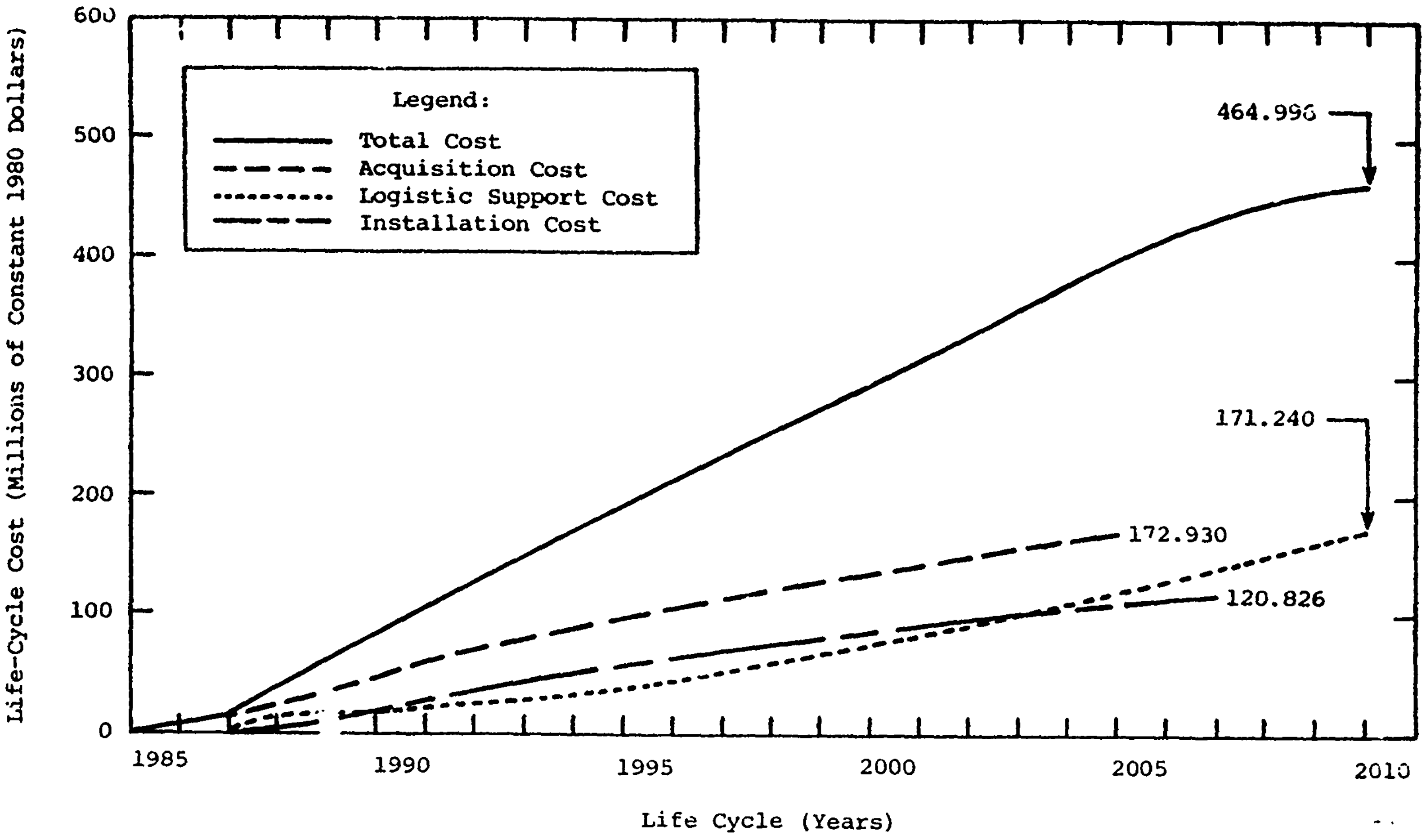

Figure 5-2. CUMULATIVE LIFE-CYCLE COST FOR BASIC I -- 464 SYSTEMS, 180-SYSTEM PRODUCTION QUANTITY

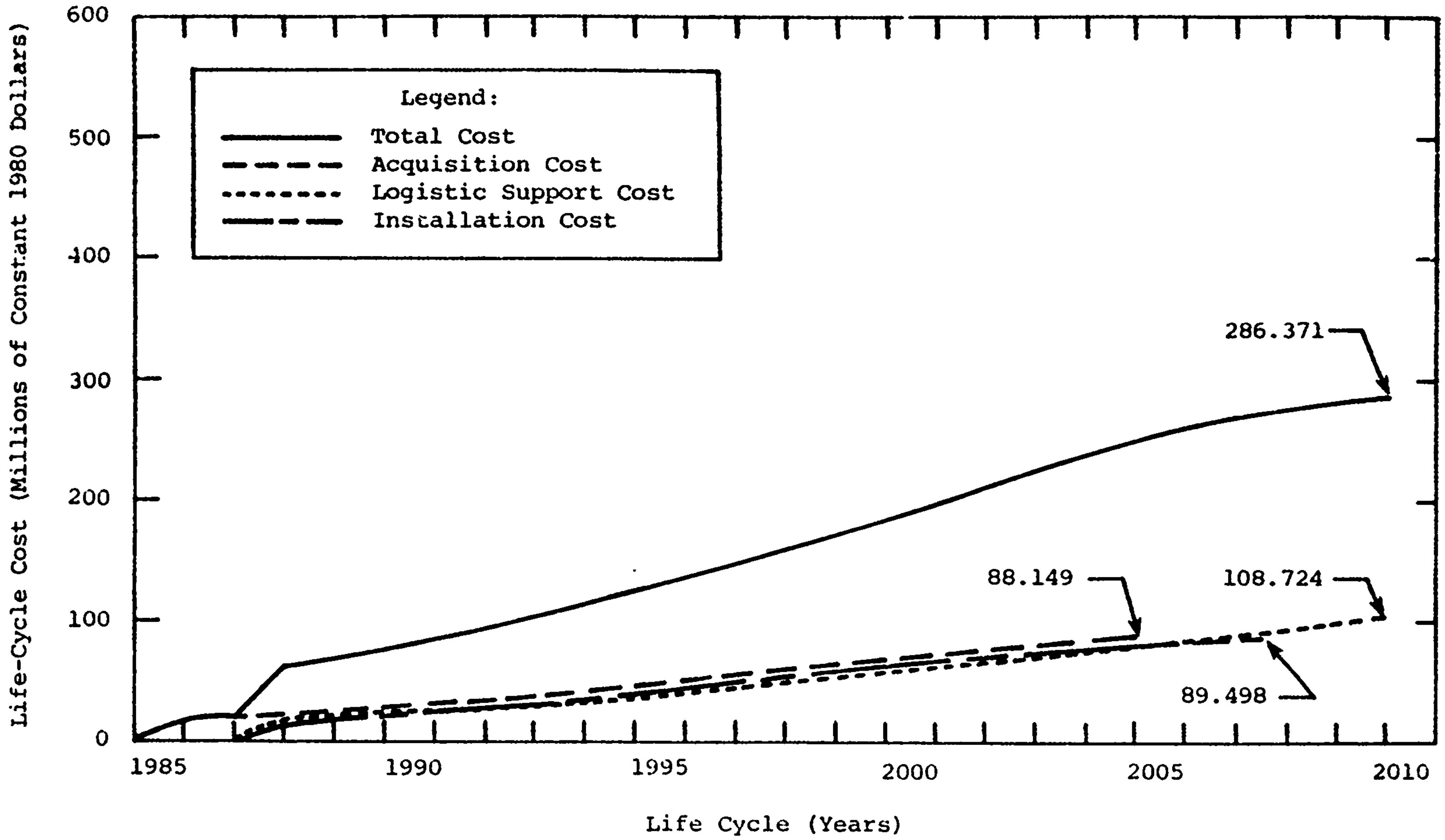

Figure 5-3. CUMULATIVE LIFE-CYCLE COST FOR SCMLS -- 463 SYSTEMS, 180-SYSTEM PRODUCTION QUANTITY

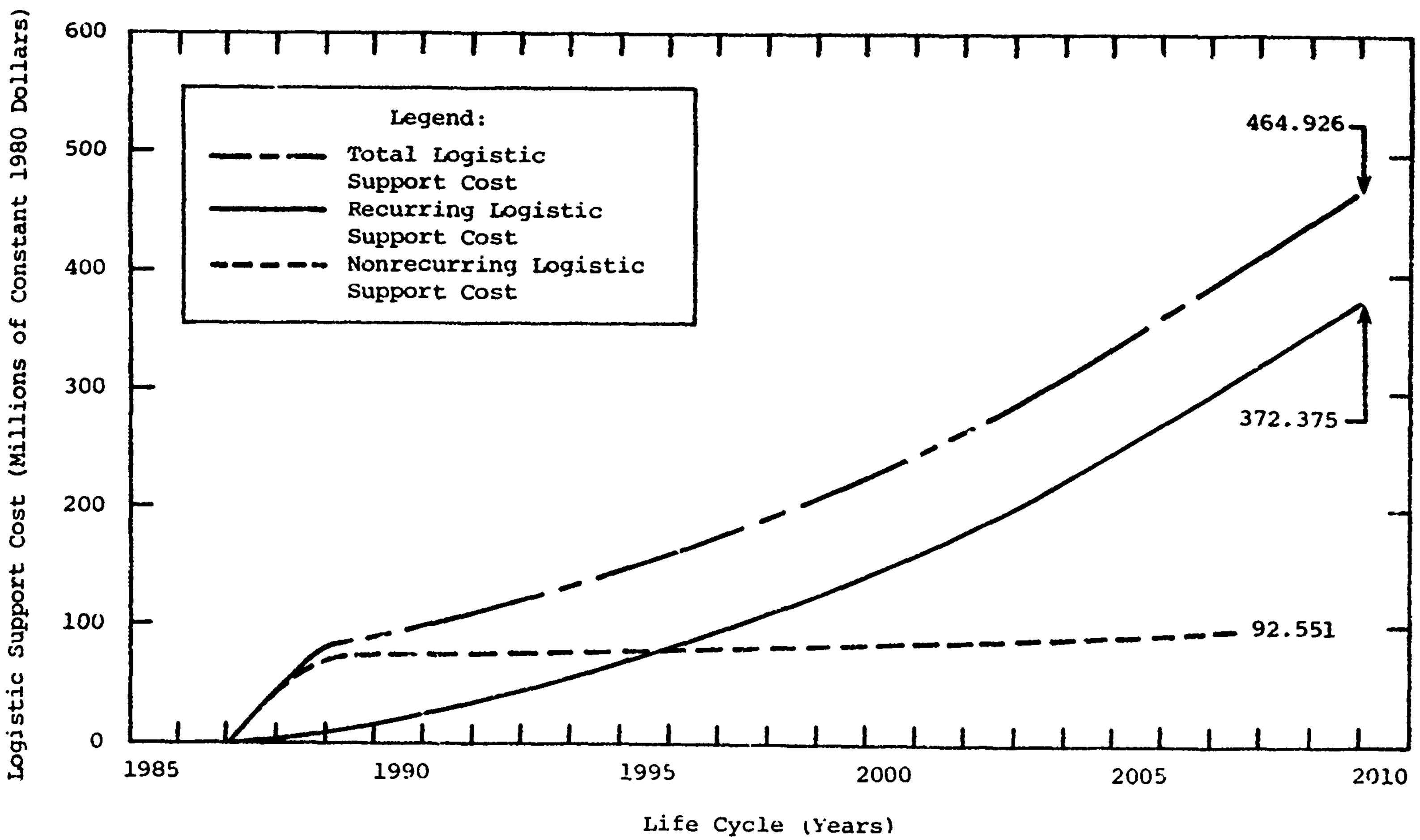

Figure 5-4. CUMULATIVE LOGISTIC SUPPORT COST -- TOTAL SYSTEM IMPLEMENTATION, 180-SYSTEM PRODUCTION QUANTITY

Table 5-3. CUMULATIVE LOGISTIC SUPPORT COSTS FOR MLS GROUND SYSTEMS

Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS	SCMLS Back Azimuth	Basic I	Basic I Back Azimuth	Basic II	Expanded	
Nonrecurring C							
Spares*	7.674	2.138	13.023	2.512	11.803	10.341	47.491
Inventory Management	0.036	0.000	0.037	0.000	0.037	0.037	0.147
Support Equipment	0.190	0.190	0.098	0.098	0.098	0.098	0.772
Training	0.660	0.033	1.189	0.123	0.775	0.278	3.058
Data Management	15.720	0.000	7.860	0.000	7.860	7.860	39.300
Transportation	0.424	0.025	0.770	0.117	0.335	0.112	1.783
Total	24.704	2.386	22.977	2.850	20.908	18.726	92.551
Recurring Costs							
Spares*	29.540	3.171	65.003	9.276	36.132	24.891	168.013
On-Site Maintenance	26.056	1.418	44.955	4.797	21.590	9.286	108.102
Off-Site Maintenance	14.220	0.342	21.330	1.197	7.417	3.041	48.147
Inventory Management	0.104	0.000	0.107	0.000	0.102	0.102	0.415
Support Equipment	0.011	0.000	0.039	0.002	0.030	0.014	0.096
Training	0.963	0.050	1.688	0.176	0.812	0.347	4.036
Data Management	7.176	0.000	2.153	0.000	2.059	2.059	13.447
Facilities	1.794	0.000	1.794	0.000	1.716	1.716	7.020
Site Operation	4.156	0.210	10.594	0.397	5.478	2.264	23.099
Total	84.020	5.191	148.263	15.845	75.336	43.720	372.375

*Spares costs are based on a three-year production run of 180 SCMLS or 180 Basic systems.

5.3.2.1 Nonrecurring Logistic Support Cost

Nonrecurring logistic support costs are costs associated with the initial deployment of a system -- including costs for providing the initial spares and support equipment required to stock the pipelines and all maintenance facilities, for introducing new coded supply items in the user inventory, for training maintenance personnel to work on the MLS equipment, for providing the necessary technical manuals and other documentation, and for transporting the system to its initial destination. All of these cost elements and their equations are explained more fully in Appendix D.

Nonrecurring costs occur when the system is deployed. This is the reason for the large jump in the LCC shown in Figures 5-1, 5-2, and 5-3. Figure 5-4 illustrates comparatively little growth in the nonrecurring logistics curve over the life cycle. This is to be expected, because once the system is introduced, most costs become recurring. However, stocking objectives must be maintained at constant levels. Spares lost to accidents, theft, or in the pipeline are accounted for by the condemnation factor and replaced as nonrecurring.

5.3.2.2 Recurring Logistic Support Cost

Recurring logistic support costs are costs associated with operating and maintaining the deployed MLS over its active life. Figure 5-4 illustrates the expected increase in recurring logistic support cost as the number of systems deployed is increased. The major contributors to recurring logistic support costs are the costs associated with spares and on- and off-site maintenance.

Other recurring logistic support costs include those for operating the MLS sites and the maintenance support equipment when used, training additional MLS maintenance personnel as a result of repair personnel turnover, and keeping the technical documentation current over the life of the system.

The facilities cost element represents the recurring operating cost of the hub or depot maintenance facility, which is apportioned to the MLS. This includes costs for rent, electricity, and general tools. It was assumed that no new maintenance facilities would be required for the MLS, since all maintenance would be performed within the centralized maintenance hub. Therefore, all required central monitoring equipment was considered to be in place at the facility. Facility costs were assumed to be a fixed $1,000 for each MLS configuration (other than back azimuth) associated with each maintenance hub over the entire life cycle.

The recurring on- and off-site maintenance costs illustrated in Table 5-3 include the cost of labor and the material cost of repair associated with each maintenance action. On-site maintenance includes both corrective and preventive maintenance; off-site maintenance includes both hub and depot-level repair.

Table 5-4 illustrates the cumulative labor costs associated with maintaining the various MLS configurations over the 25-year life cycle. These costs are dependent on the implementation strategy employed and the MTBF associated with each subassembly of each MLS configuration; they are independent of the actual cost of the MLS system or subassembly, however, because they are predicated on actual maintenance hours required.

On- and off-site maintenance costs were calculated on the basis of maintenance hours devoted to the MLS rather than the cost of maintaining a minimum maintenance staff capable of providing 24 hours of maintenance coverage for the MLS. To calculate training costs, we assumed that a minimum staff of five people plus one floater would be assigned to a maintenance hub, although these personnel would not be dedicated to the MLS. We computed the training costs so that there would be an 84 percent probability that a technician would be available to work on the MLS when required.

More interesting are the expected annual maintenance costs associated with full system deployment. These costs are presented in Table 5-5 in both dollars and the expected annual maintenance hours required for each system

Table 5-4. CUMULATIVE LABOR COSTS FOR MLS GROUND SYSTEMS

Labor Category	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS	SCMLS Back Azimuth	Basic I	Basic I Back Azimuth	Basic II	Expanded	
Corrective Maintenance	21.024	0.891	37.856	3.721	18.454	7.872	89.818
Preventive Maintenance	1.999	0.380	1.956	0.543	0.714	0.394	5.986
Base-Level Repair	3.239	0.133	8.471	0.757	4.408	1.727	1[illegible].735
Depot-Level Repair	0.202	0.008	0.524	0.047	0.273	0.107	1.161
Total	26.464	1.412	48.807	5.068	23.849	10.100	115.700

Table 5-5. EXPECTED ANNUAL MAINTENANCE COSTS WITH FULL SYSTEM DEPLOYMENT

Labor Category	Cost by System Type (Millions of Constant 1980 Dollars)												Total	
	SCMLS (463 Systems)		SCMLS Back Azimuth (46 Systems)		Basic I (464 Systems)		Basic I Back Azimuth (92 Systems)		Basic II (188 Systems)		Expanded (62 Systems)			
	Hours*	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost
Corrective Maintenance	98.9	1.442	4.1	0.060	183.0	2.669	18.1	0.265	120.9	1.763	43.6	0.636	468.6	6.835
Preventive Maintenance	8.5	0.133	0.8	0.021	8.5	0.133	1.7	0.033	3.5	0.059	1.1	0.025	24.1	0.404
Base-Level Repair	12.8	0.223	0.5	0.009	34.3	0.598	3.1	0.054	24.3	0.423	8.1	0.140	83.1	1.447
Depot-Level Repair	0.7	0.014	0.0	0.001	1.8	0.037	0.2	0.003	1.3	0.026	0.4	0.009	4.4	0.090
Total	120.9	1.812	5.4	0.091	227.6	3.437	23.1	0.355	150.0	2.271	53.2	0.810	580.2	8.776

*Thousands of hours.

configuration and the four maintenance categories. These costs assume that the maintenance scenario of Chapter Four is used; they are illustrated for the twenty-fifth year of the life cycle. Therefore, they include replacement of shelters, antennas, chassis, and other items that would be replaced on site.

5.4 DISCOUNTED LIFE-CYCLE COSTS

OMB Circular A-94 requires that life-cycle costs be discounted to reflect the opportunity cost of money. This means that money spent during a particular year has a greater impact on cost than does money spent one year later (assuming that all economic factors remain constant). The expected opportunity cost is the fact that the money spent could have been invested to yield a rate of return. OMB specifies that because the expected rate of return is 10 percent, money should be discounted at 10 percent. Thus, one 1980 dollar will be worth approximately 62¢ in 1985 when the MLS acquisition begins, 15¢ when acquisition ends, and 9¢ when the life-cycle analysis is terminated.

We discussed the assumption of a 10 percent discount with OSEM-200 personnel and developed best-case and worst-case economic scenarios for the next eight years. We considered productivity, cost of capital, inflation rates, and expected technological changes. The variability in rates when these considered factors were combined predicted a rate of return of 9 percent in the worst case and 10.5 percent in the best case. Since these numbers very nearly reflect the requirements of OMB A-94, a discount rate of 10 percent was used for our analysis.

The tabulated results for a production run of 180 systems is shown in Table 5-6; the cumulative total is graphically illustrated in Figure 5-5 and compared with the total nondiscounted LCC of Figure 5-1.

Table 5-6. LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS OR 180 BASIC SYSTEMS (MILLIONS OF DOLLARS, USING A DISCOUNT RATE OF 10 PERCENT)

Cost Category	Cost by System Type						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	28.809	1.085	52.684	4.308	22.653	10.201	119.740
Installation	24.173	0.176	30.422	0.572	8.834	4.517	68.694
Nonrecurring Logistics	11.501	1.163	8.732	1.243	8.057	8.223	38.919
Recurring Logistics	14.282	1.018	23.353	2.767	11.087	7.672	60.179
Total	78.765	3.442	115.191	8.890	50.631	30.613	287.532

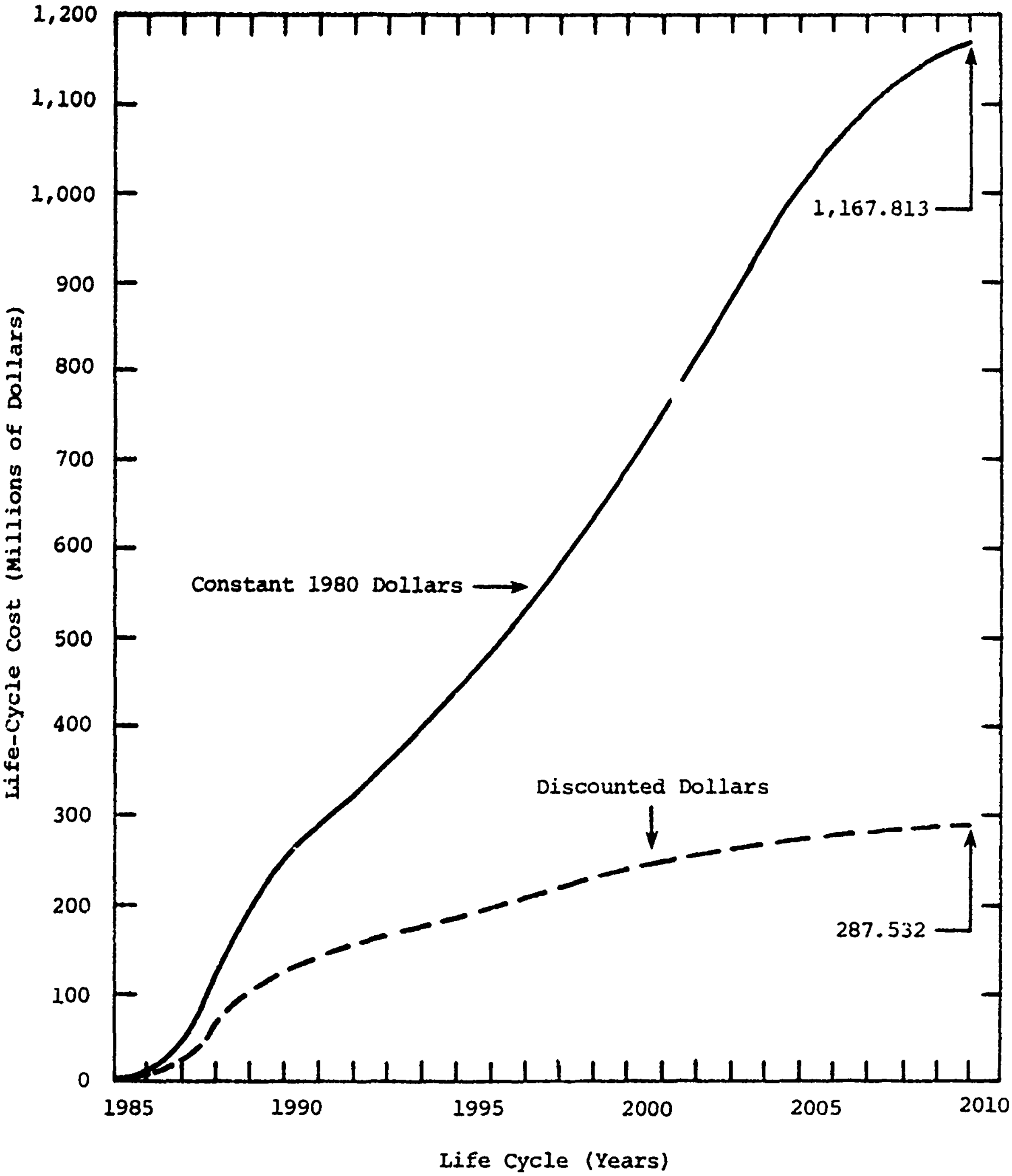

Figure 5-5. LIFE-CYCLE COST -- TOTAL SYSTEM IMPLEMENTATION, 180-SYSTEM PRODUCTION QUANTITY

CHAPTER SIX

SENSITIVITY OF THE MLS GROUND SYSTEM COST ANALYSES TO PARAMETER VARIATIONS AND ALTERNATIVE ASSUMPTIONS

When the data in Chapters Three, Four, and Five were developed for the cost analyses of the MLS ground system concepts, assumptions had to be made regarding system configurations, reliability, and implementation scenarios. A change in these assumptions would affect the overall costs. Because of this fact and the fluid environment in which MLS decisions are necessarily made, the EAM was exercised to determine cost sensitivity to alternative scenarios.

The cases considered in these other scenarios were as follows:

- Sensitivity of life-cycle costs to variations in system MTBFs
- Shelters versus weatherproof enclosures for Basic I MLS sites
- Use of an azimuth beamwidth of 2° in lieu of 3° for the SCMLS
- Coverage of 40° for the SCMLS
- Implementation strategies
- Production schedules for MLS equipments

6.1 SENSITIVITY OF LIFE-CYCLE COST TO VARIATIONS IN MTBF

In an economic analysis of any system, MTBF is usually difficult to predict accurately. However, it has a major impact on the life-cycle cost, especially when the spares cost is statistically dependent on the MTBF of each subassembly. Because we took the MTBF from PRICE or GIFRDE data instead of conducting an in-depth reliability analysis of the MLS subassemblies, we evaluated the effect of variations in MTBF on the life-cycle costs of MLS ground systems. Figure 6-1 illustrates the effect that variations in the parametric MTBFs would have on the life-cycle costs predicted for the various MLS configurations and for the entire system implementation.

Since each MLS configuration has a unique MTBF, the configurations were normalized to allow a comparison of systems and a projection of the impact that variations in MTBF would have on the total system implementation. Figure 6-1 illustrates that in general, the LCCs of the SCMLS, Basic II, and Expanded configurations are relatively insensitive to variations in MTBF. The Basic I configuration appears to be the most sensitive, as it lies the

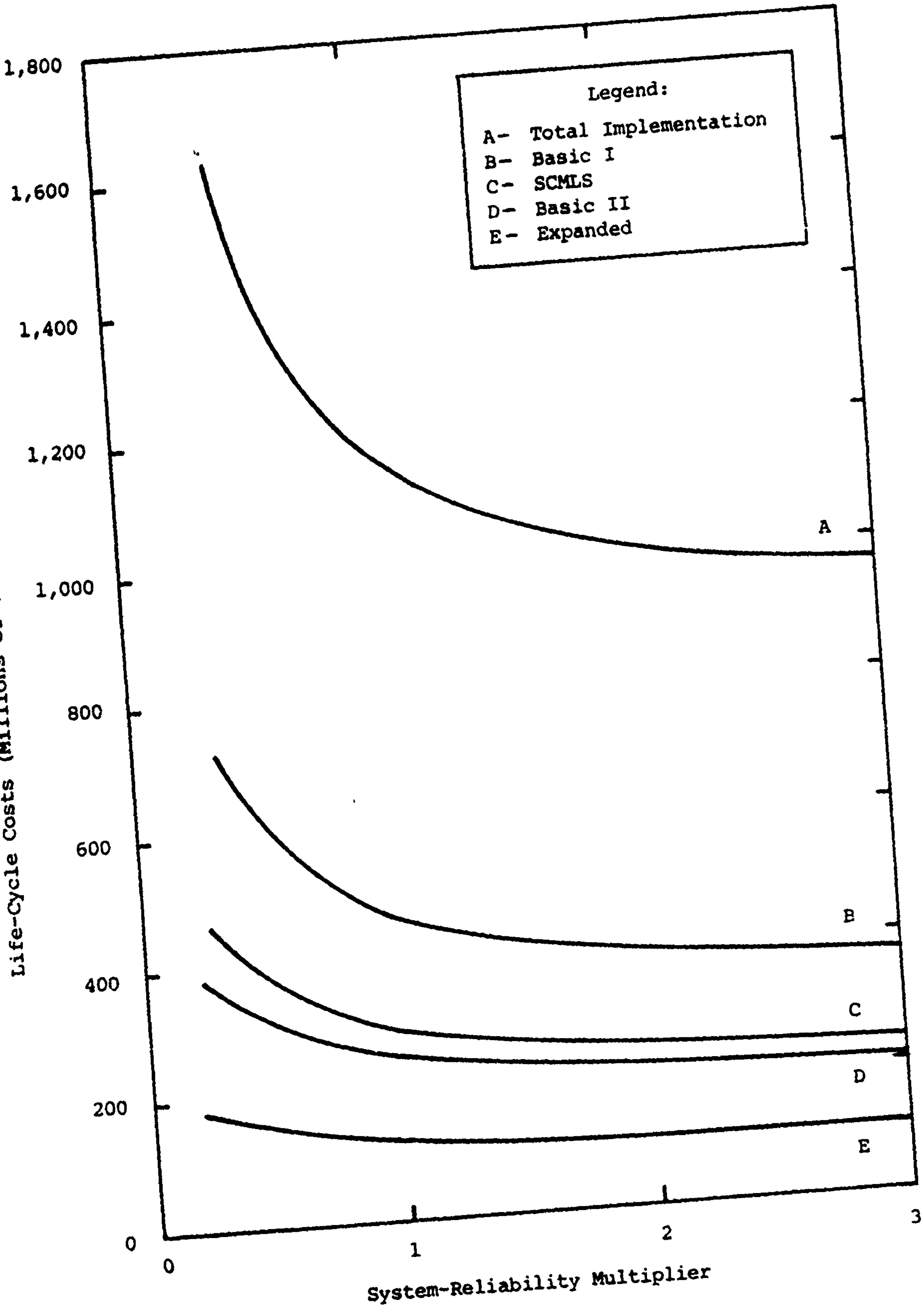

Figure 6-1. LIFE-CYCLE COST VARIABILITY WITH CHANGES IN SYSTEM MTBF

farthest on the knee of the cost-versus-MTBF curve. This insensitivity to MTBF is not unexpected, because in the centralized maintenance scenario, maintenance costs are not a dominating cost driver in the LCC. This is easily seen in Table 5-2, which shows that recurring logistics, installation, and acquisition costs are of the same relative magnitude, and in Table 5-3, which shows that of the recurring and nonrecurring logistic support costs, maintenance-peculiar items make up only about 13 percent of the life-cycle costs.

The total implementation curve in Figure 6-1 shows the cumulative effect of MTBF variations. The curve trend appears to be dominated by the Basic I system, which is expected because of the number of these systems implemented. The normalized MTBFs shown in Figure 6-1 are total system serial reliabilities and include not only active electronics, but enclosures, air conditioners, and all the peripheral equipment that make up a complete MLS configuration.

6.2 SHELTERS VERSUS WEATHERPROOF ENCLOSURES

The MLS is designed to be installed with weatherproof enclosures or in shelters. Redundant electronics associated with the Basic II and Expanded configurations are expected to be housed in shelters because of the quantity of equipment; SCMLS equipment is expected to be housed in weatherproof enclosures because of the small quantity of equipment. Basic I equipment may be housed in either weatherproof enclosures or shelters, depending on the desired implementation policy. Since the baseline analysis was directed toward a Basic I configuration in a shelter, we investigated the alternative scenario of Basic I housed in a weatherproof enclosure.

We assumed a packaging of the electronics in nonenvironmentally controlled, weatherproof cabinets, with an assumed cabinet cost of $1,500. The shelters and air conditioners were eliminated, for an approximate saving in equipment costs of $35,000. Installation costs were also reduced by the elimination of the shelter concrete pads, the wiring and trenching from the shelters to the antennas, and the waveguide-pressurization requirement. This resulted in a reduction in installation costs of approximately $35,000. The total reduction per installation was $70,000. No repackaging of DME was considered.

Table 6-1 compares the life-cycle costs associated with Basic I shelters and weatherproof enclosures. Acquisition costs are reduced by approximately 10 percent and installation costs by 13 percent. The costs of nonrecurring logistics are approximately the same, as is expected, since, as illustrated in Table 6-2, the initial nonrecurring costs are overwhelmingly influenced by initial spares, training, and data management. These costs would not change if the equipment reliabilities were not affected by the weatherproof enclosure. There is a small change in initial shipping costs because of the reduction in shipping weight.

Table 6-1. LIFE-CYCLE COSTS FOR BASIC I MLS SHELTER CONFIGURATIONS, BASED ON THREE-YEAR PRODUCTION RUN, 180 BASIC SYSTEMS		
Cost Category	Cost by Configuration (Millions of Constant 1980 Dollars)	
	Shelters	Weatherproof Enclosures
Acquisition	172.930	155.818
Installation	120.826	104.725
Nonrecurring Logistics	22.977	22.734
Recurring Logistics	148.263	130.622
Total	464.996	413.899

With the exception of recurring spares, Table 6-2 shows no basic change in recurring costs. These recurring spares are the shelters themselves. Each shelter was assumed to have an MTBF of 15 years. A deployment of 464 Basic I systems would require 928 shelters. Under the implementation schedule of strategy 9, the MTBF over a 25-year life cycle would necessitate replacement of 528 of these shelters at a cost of approximately $10.3 million (1980 dollars). Figure 6-2 graphically illustrates the life cycle for a shelterized Basic I MLS and a Basic I MLS in a weatherproof enclosure. The total life-cycle cost for a weatherproof-enclosed Basic I configuration is approximately 11 percent less than that for a shelterized Basic I configuration for the given implementation strategy.

6.3 AZIMUTH BEAMWIDTH AND COVERAGE FOR SCMLS

The thinned-array SCMLS configuration of 3° azimuth and 2° elevation is representative of the prototype SCMLS. The 3° azimuth beamwidth could be runway-length constrained under conditions of severe multipath. A configuration with a narrower beamwidth would obviously be less constrained. The SCMLS configurations were also limited in proportional guidance coverage to $\pm 10°$ because of the thinned-array technique employed. To investigate cost versus versatility of the SCMLS configurations, we assumed a new design for a 2° azimuth beamwidth SCMLS and a $\pm 40°$ proportional guidance azimuth SCMLS.

6.3.1 2° Azimuth Beamwidth SCMLS

To obtain a 2° azimuth beamwidth SCMLS, we expanded the azimuth chassis and radome to accommodate 4 additional phase shifters and 16 additional

Table 6-2. CUMULATIVE LOGISTIC SUPPORT COSTS FOR BASIC I MLS SHELTER CONFIGURATIONS		
Cost Category	Cost by Configuration (Millions of Constant 1980 Dollars)	
	Shelters	Weatherproof Enclosure
Nonrecurring Costs		
Spares*	13.023	13.023
Inventory Management	0.037	0.037
Support Equipment	0.098	0.098
Training	1.189	1.182
Data Management	7.860	7.860
Transportation	0.770	0.534
Total	22.977	22.734
Recurring Costs		
Spares*	65.003	47.605
On-Site Maintenance	44.955	44.774
Off-Site Maintenance	21.930	21.876
Inventory Management	0.107	0.107
Support Equipment	0.039	0.038
Training	1.688	1.681
Data Management	2.153	2.153
Facilities	1.794	1.794
Site Operations	10.594	10.594
Total	148.263	130.622

*Spares costs are based on a three-year production run of 180 systems.

waveguide elements, in accordance with Hazeltine literature describing ways to expand the COMPACT™ array. Changes were made to the antenna PCB and column radiator to increase their length. Other changes were made in connectors and power dividers. It was assumed that no changes were required in the electronics and power supplies that would affect cost. The overall change in acquisition cost was approximately $6,400 for the azimuth antenna subsystem, or an increase in price of approximately 10 percent.

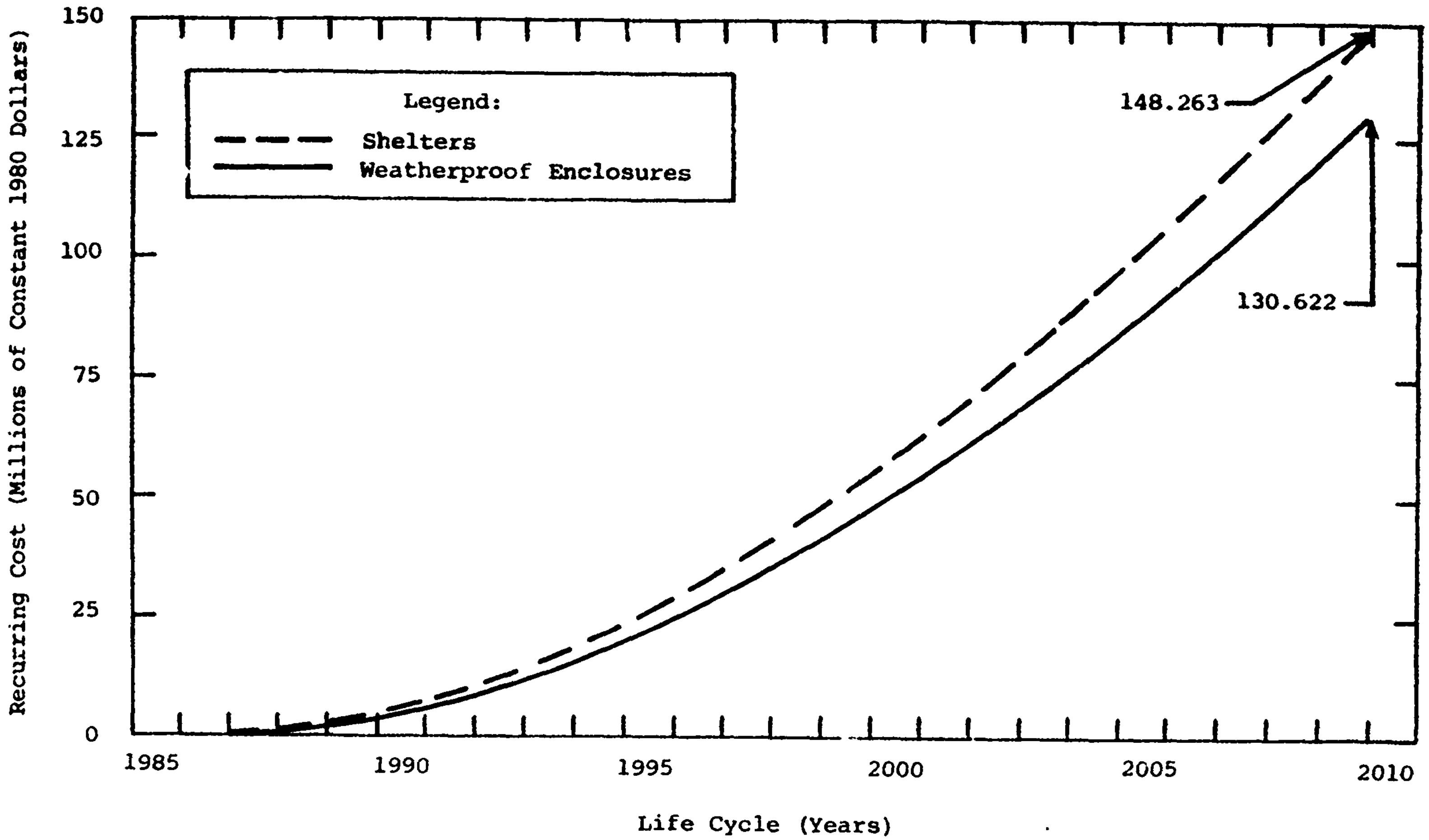

Figure 6-2. CUMULATIVE RECURRING LOGISTIC SUPPORT COSTS FOR BASIC I MLS IN SHELTERS OR WEATHERPROOF ENCLOSURES

6.3.2 ±40° Proportional Guidance Coverage SCMLS

A thinned-array concept is of itself limited in coverage. Ordinary thinning can result in high sidelobes. The COMPACT™ system was developed to produce accurate beam scanning while maintaining acceptable sidelobe levels. To achieve a wide-coverage scan with the SCMLS of this study, the array must be refilled so that each element is excited by its own phase shifter. Thus, to attain a ±40° coverage, 3° azimuth beamwidth SCMLS, we added adequate phase shifters, drivers, and connectors to fill the antenna array. An increased cost was assumed for the BSU, monitor electronics, antenna PCB, and column radiator. There were no changes assumed to be required for the azimuth chassis, radome, or power supplies. The overall change in acquisition cost from the ±10° coverage, 3° azimuth beamwidth SCMLS would be approximately $18,300, or an increase in the azimuth subsystem of 29 percent.

The same coverage assumptions were applied to the 2° azimuth beamwidth system to determine the acquisition cost for a ±40° coverage, 2° azimuth beamwidth system. The cost of this azimuth subsystem would be approximately $29,000 over the ±10° coverage, 3° azimuth beamwidth -- an increase in acquisition cost of approximately 46 percent.

6.3.3 Cost Impacts

Table 6-3 compares the life-cycle costs associated with the different SCMLS azimuth configurations and illustrates the expected increase in acquisition and nonrecurring and recurring logistic support costs with increased SCMLS accuracy and coverage capabilities. A narrower beamwidth results in an increase in life-cycle cost of approximately 3 percent, while wider coverage incurs a 9.5 percent increase. A narrower beamwidth combined with wider coverage results in an increase in life-cycle cost of approximately 15 percent.

Table 6-3. LIFE-CYCLE COSTS FOR DIFFERENT SCMLS AZIMUTH CONFIGURATIONS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS

Cost Category	Cost by SCMLS Configuration (Millions of Constant 1980 Dollars)			
	3° Azimuth ±10° Coverage	2° Azimuth ±10° Coverage	3° Azimuth ±40° Coverage	2° Azimuth ±40° Coverage
Acquisition	88.149	91.184	96.873	102.045
Installation	89.498	89.498	89.498	89.498
Nonrecurring Logistics	24.704	25.006	25.879	26.447
Recurring Logistics	84.020	89.651	101.324	112.020
Total	286.371	295.339	313.574	330.010

Table 6-4 separates the logistics costs of Table 6-3 into the various logistic support cost categories and illustrates that the cost drivers in the logistic support costs are spares and on-site maintenance. This is because the increased parts associated with the various SCMLS configurations reduce the overall system reliability and increase the demand for spare parts and on-site maintenance.

Table 6-4. CUMULATIVE LOGISTIC SUPPORT COSTS FOR DIFFERENT SCMLS AZIMUTH CONFIGURATIONS

Cost Category	Cost by SCMLS Configuration (Millions of Constant 1980 Dollars)			
	3° Azimuth ±10° Coverage	2° Azimuth ±10° Coverage	3° Azimuth ±40° Coverage	2° Azimuth ±40° Coverage
Nonrecurring Costs				
Spares*	7.764	7.922	8.716	9.189
Inventory Management	0.036	0.036	0.036	0.039
Support Equipment	0.190	0.190	0.190	0.190
Training	0.660	0.714	0.793	0.885
Data Management	15.720	15.720	15.720	15.720
Transportation	0.424	0.424	0.424	0.424
Total	24.704	25.006	25.879	26.447
Recurring Costs				
Spares*	29.540	32.932	41.344	48.206
On-Site Maintenance	26.056	28.167	31.356	35.005
Off-Site Maintenance	14.220	14.268	14.220	14.268
Inventory Management	0.104	0.104	104	0.104
Support Equipment	0.011	0.014	0.[illegible]7	0.022
Training	0.963	1.040	1.157	1.289
Data Management	7.176	7.176	7.176	7.176
Facilities	1.794	1.794	1.794	1.794
Site Operations	4.156	4.156	4.156	4.156
Total	84.020	89.651	101.324	112.020

*Spares costs are based on a three-year production run of 180 SCMLS.

6.4 IMPLEMENTATION STRATEGIES

The costs determined in this study are directly affected by the MLS implementation strategy employed. The EAM integrated acquisition costs, installation costs, and implementation strategy to develop the life-cycle costs. To test the sensitivity of the LCC to the implementation strategy and to investigate alternative methods of implementation, we analyzed three different strategies derived from the basic implementation scenario. We also investigated a new implementation strategy designed around a 1,250-system acquisition over 15 years.

6.4.1 Faster Implementation Rates

The implementation strategy used in the LCC study was based on a 20-year acquisition and deployment schedule. Using the same guidelines with respect to quantities of systems deployed, we developed 10-year and 15-year acquisition and deployment schedules.

The 10-year schedule was developed by combining the systems acquired during the first two years of the 20-year plan (see Table 4-3) into the first year, combining those acquired during the third and fourth years into the second year, and so on, until the nineteenth and twentieth years were combined to generate the tenth year of implementation. The resulting schedule is illustrated in Table 6-5.

Table 6-5. MLS GROUND SYSTEM ACQUISITION SCHEDULE WITH 10-YEAR IMPLEMENTATION

System	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Expanded	5	9	9	0	0	4	8	8	9	10	62
Basic II	8	16	15	0	0	16	32	32	34	35	188
Basic I	38	63	63	50	50	46	39	36	39	40	464
SCMLS	101	28	29	49	50	45	39	42	42	38	463
Additional Azimuth Systems to be Acquired for Back Azimuth											
Basic I	7	12	12	10	10	9	8	8	8	8	92
SCMLS	10	3	3	5	5	4	4	4	4	4	46

The 15-year schedule was developed by taking the systems acquired during the last five years of the 20-year implementation plan (see Table 4-3) and distributing them equally over the first 15 years where possible. Most of the expanded systems were left to be acquired in the later years, just as in the 20-year implementation plan. Table 6-6 shows the resulting schedule.

The intent in developing 15- and 20-year implementation plans was to acquire the same number of systems in a manner similar to that of the 20-year implementation strategy. The total acquisition, installation, and nonrecurring logistics costs will be the same for any implementation strategy

Table 6-6. MLS GROUND SYSTEM ACQUISITION SCHEDULE WITH 15-YEAR IMPLEMENTATION

System	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Expanded	0	5	5	5	6	5	0	0	0	0	0	9	9	9	9	62
Basic II	0	18	18	18	18	18	0	0	0	0	0	25	25	24	24	188
Basic I	12	40	38	39	37	39	31	33	32	32	32	24	25	25	25	464
SCMLS	94	21	21	21	21	22	31	32	31	33	33	26	27	25	25	463
Additional Azimuth Systems to be Acquired for Back Azimuth																
Basic I	2	7	7	7	7	7	7	6	6	6	6	6	6	6	6	92
SCMLS	9	3	3	3	3	3	3	3	3	3	2	2	2	2	2	46

acquiring an equal number of systems as long as constant dollars are used. The shapes of the cost trends when graphed are different, because they are occurring at different rates. Accordingly, these three costs are not presented here. Recurring logistics costs are time-dependent, however, even in constant dollars, because spares and maintenance actions depend on system MTBF. A faster implementation rate would increase the recurring logistics costs.

Table 6-7 summarizes the cumulative recurring logistic support costs associated with the three implementation schedules. Table 6-8 breaks these costs down into the recurring logistic support costs component parts and illustrates that the percentage increase in recurring costs with more rapid implementation is dependent on the system configuration deployed. The largest increases in cost are from spares and on- and off-site maintenance. As expected, site operations costs also increase with a more rapid deployment.

Table 6-7. TOTAL RECURRING LOGISTIC SUPPORT COSTS FOR MLS GROUND SYSTEMS WITH DIFFERENT IMPLEMENTATION STRATEGIES

Implementation Plan	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS		Basic				
	SCMLS	Back Azimuth	Basic I	Back Azimuth	Basic II	Expanded	
10-Year	106.013	5.804	192.321	19.289	112.425	55.394	491.246
15-Year	95.015	5.570	168.717	17.226	101.317	47.957	435.802
20-Year	84.020	5.191	148.263	15.845	75.336	43.720	372.375

Figure 6-3 illustrates the recurring cost trends associated with the different implementation schedules. The curve for the 10-year implementation schedule illustrates that recurring costs become essentially constant after the system is fully deployed.

6.4.2 Single-System Implementation

As an alternative implementation strategy, we investigated implementing only one type of MLS configuration. For this analysis we used the 20-year implementation strategy and combined the number of different systems acquired in any one year into a total number for acquiring one system in that year. We chose the Basic I system as the system to be implemented. While it was assumed that 20 percent of the back azimuth systems would be implemented, those costs are not included in the following tables; thus, a direct comparison may be made between total systems implemented.

Table 6-8. CUMULATIVE RECURRING LOGISTIC SUPPORT COSTS FOR MLS GROUND SYSTEMS WITH DIFFERENT IMPLEMENTATION STRATEGIES

Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)								
	SCMLS			SCMLS Back Azimuth			Basic I		
	10-Year	15-Year	20-Year	10-Year	15-Year	20-Year	10-Year	15-Year	20-Year
Spares	37.778	33.648	29.540	3.262	3.227	3.171	82.968	73.388	65.003
On-Site Maintenance	33.905	29.986	26.056	1.766	1.633	1.418	59.713	51.781	44.955
Off-Site Maintenance	18.562	16.394	14.220	0.442	0.403	0.342	29.190	25.288	21.930
Inventory Management	0.104	0.104	0.104	0.000	0.000	0.000	0.107	0.107	0.107
Support Equipment	0.015	0.013	0.011	0.000	0.000	0.000	0.051	0.045	0.039
Training	1.254	1.109	0.963	0.063	0.059	0.050	2.244	1.945	1.688
Data Management	7.176	7.176	7.176	0.000	0.000	0.000	2.153	2.153	2.153
Facilities	1.794	1.794	1.794	0.000	0.000	0.000	1.794	1.794	1.794
Site Operation	5.475	4.791	4.156	0.271	0.248	0.210	14.101	12.216	10.594
Total	106.013	95.015	84.020	5.804	5.570	5.191	192.321	168.717	148.263

Cost Category	Basic I Back Azimuth			Basic II			Expanded		
	10-Year	15-Year	20-Year	10-Year	15-Year	20-Year	10-Year	15-Year	20-Year
Spares	10.567	9.780	9.276	50.982	46.553	36.132	29.655	26.554	24.891
On-Site Maintenance	6.348	5.429	4.797	35.004	31.047	21.590	13.429	10.867	9.286
Off-Site Maintenance	1.606	1.364	1.197	12.091	10.713	7.417	4.436	3.575	3.041
Inventory Management	0.000	0.000	0.000	0.102	0.102	0.102	0.102	0.102	0.102
Support Equipment	0.002	0.002	0.002	0.050	0.044	0.030	0.020	0.016	0.014
Training	0.233	0.199	0.176	1.319	1.170	0.812	0.503	0.407	0.347
Data Management	0.000	0.000	0.000	2.153	2.059	2.059	2.153	2.059	2.059
Facilities	0.000	0.000	0.000	1.794	1.716	1.716	1.794	1.716	1.716
Site Operation	0.533	0.452	0.397	8.930	7.913	5.478	3.302	2.661	2.264
Total	19.289	17.226	15.845	112.425	101.317	75.336	55.394	47.957	43.720

Table 6-9 shows the life-cycle costs associated with the single-system implementation strategy and shows the total costs from Table 5-2, with the SCMLS and Basic I back azimuth systems eliminated for comparison purposes. Table 6-9 also shows that a single-system implementation is more costly in the acquisition and installation cost categories. Since the lower-cost SCMLS configurations were eliminated from consideration, this is not unexpected. Nonrecurring logistic support costs are about 35 percent less than those for the four-system implementation; recurring logistic support costs are essentially equal.

Table 6-10 illustrates the cumulative logistic support costs of the all-Basic I implementation and compares these costs with those from Table 5-3. The cost of initial spares is about $15 million less than for the four-system implementation. The other nonrecurring costs are approximately equal, with the exception of data management. Data management is less because of the single configuration (Basic) versus the SCMLS and Basic configurations in the mixed-system implementation.

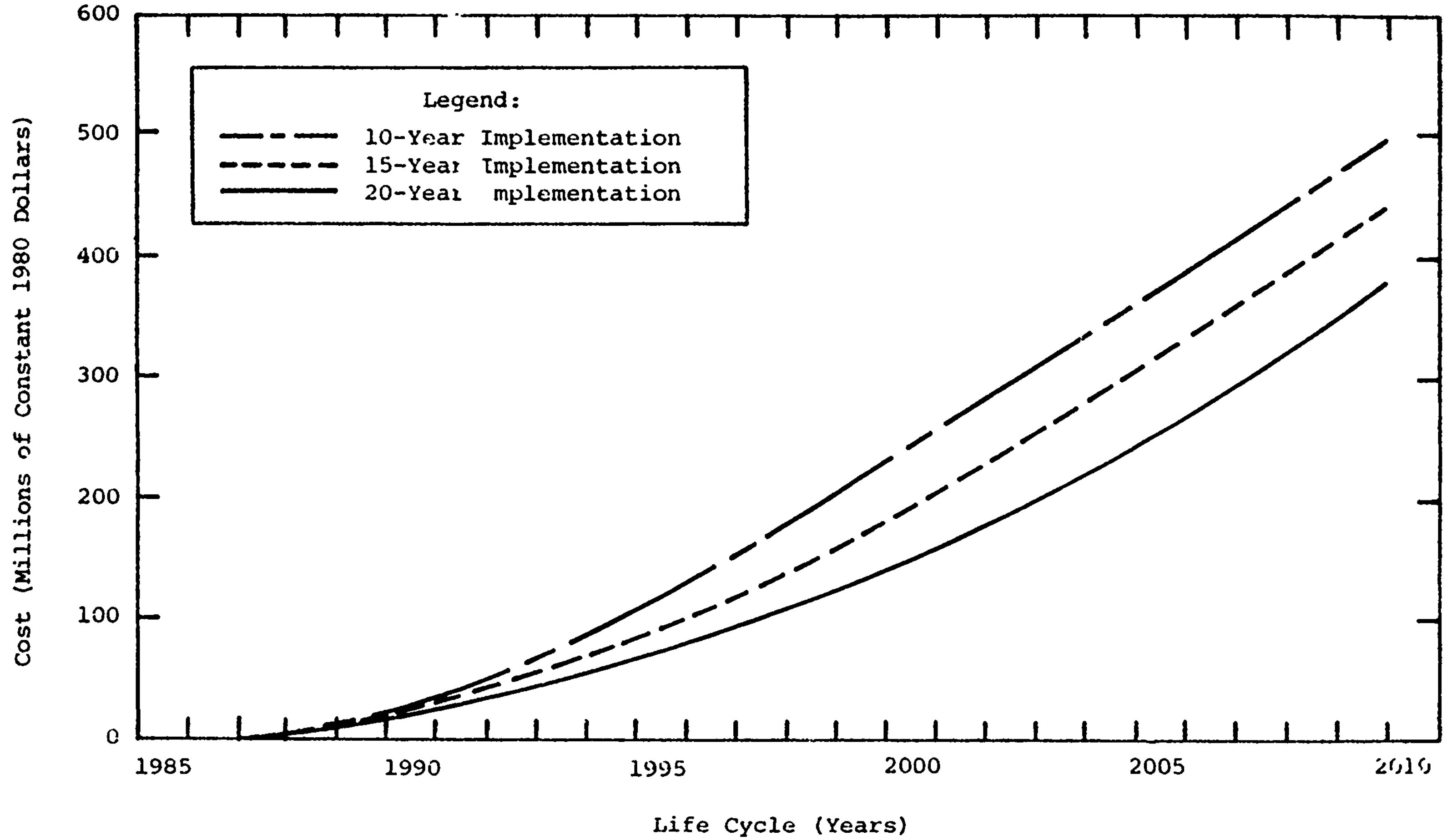

Figure 6-3. CUMULATIVE RECURRING LOGISTIC SUPPORT COSTS FOR 10-, 15-, AND 20-YEAR IMPLEMENTATION PERIODS

Table 6-9. LIFE-CYCLE COSTS FOR DIFFERENT IMPLEMENTATION STRATEGIES		
Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)	
	All Basic (1,177 Systems)	Mixed Implementation (1,177 Systems)
Acquisition	438.660	402.744
Installation	302.724	279.591
Nonrecurring Logistics	56.748	87.315
Recurring Logistics	343.521	351.339
Total*	1,141.653	1,120.989

*No back azimuth costs are included in totals.

Table 6-10 shows the cost of recurring spares to be about 6 percent less than that associated with the four-system implementation. This is true even though the Basic I configuration would be implemented with shelters. Such an implementation means that we would install 926 more shelters than with the strategy employed in Chapter Five. This is important to note considering the impact of shelters on spares as previously discussed. On- and off-site maintenance costs are higher with the single-system implementation. As shown in Table 6-2, maintenance costs do not change significantly between the shelters and weatherproof enclosure configurations.

Tables 6-11 and 6-12 present the cumulative labor costs and expected annual maintenance costs, respectively, for the single-system implementation and compare these costs with those from Chapter Five. Table 6-11 shows that corrective maintenance costs and both base-level and depot-level repair costs are higher with the single-system implementation; preventive maintenance costs are slightly lower. Table 6-12 shows that more annual maintenance hours would be required with the single-system implementation, at a cost of approximately $0.35 million per year. This is due in part to the removal of the relatively simple SCMLS configuration from the implementation.

6.4.3 Transition Plan Strategy

During the course of this LCC study, a new transition plan strategy was developed by the FAA, requiring implementation of 1,250 systems over a 15-year period. Since no mix of systems was hypothesized, we used the same

Table 6-10. CUMULATIVE LOGISTIC SUPPORT COSTS		
Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)	
	All Basic (1,177 Systems)	Mixed Implementation (1,177 Systems)
Nonrecurring Costs		
Spares	27.804	42.841
Inventory Management	0.112	0.147
Support Equipment	0.294	0.484
Training	3.004	2.902
Data Management	23.580	39.300
Transportation	1.954	1.641
Total*	56.748	87.315
Recurring Costs		
Spares	146.751	155.566
On-Site Maintenance	109.000	101.887
Off-Site Maintenance	53.483	46.608
Inventory Management	0.312	0.415
Support Equipment	0.094	0.094
Training	4.097	3.810
Data Management	2.153	13.447
Facilities	1.794	7.020
Site Operations	25.837	22.492
Total*	343.521	351.339

*No back azimuth costs are included in totals.

mix used for the basic analysis to investigate this new plan, which is shown in Table 6-13. The major impact of this plan would be the acquisition of a set number of systems each year.

Table 6-11. CUMULATIVE LABOR COSTS		
Labor Category	Cost by System Type (Millions of Constant 1980 Dollars)	
	All Basic (1,177 Systems)	Mixed Implementation (1,177 Systems)
Corrective Maintenance	91.972	85.205
Preventive Maintenance	4.486	5.063
Base-Level Repair	20.658	17.845
Depot-Level Repair	1.279	1.106
Total*	118.395	109.219

*No back azimuth costs are included in totals.

Table 6-12. EXPECTED ANNUAL MAINTENANCE COSTS				
Labor Category	Cost by System Type (Millions of Constant 1980 Dollars)			
	All Basic (1,177 Systems)		Mixed Implementation (1,177 Systems)	
	Hours*	Cost	Hours	Cost
Corrective Maintenance	462.7	6.747	446.4	6.510
Preventive Maintenance	21.6	0.324	21.6	.350
Base-Level Repair	87.1	1.517	79.5	1.384
Depot-Level Repair	4.5	0.094	4.2	0.086
Total**	575.9	8.682	551.7	8.330

*Thousands of hours.
**No back azimuth costs are included in totals.

Table 6-13. **MLS GROUND SYSTEM ACQUISITION SCHEDULE FOR 1,250-SYSTEM PROCUREMENT**

System	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Expanded	0	0	3	3	5	5	5	5	5	6	6	6	6	6	6	67
Basic II	0	0	10	10	17	17	17	17	17	16	16	16	16	16	16	201
Basic I	5	10	24	24	39	39	39	39	39	39	39	39	39	39	39	492
SCMLS	5	10	23	23	39	39	39	39	39	39	39	39	39	39	39	490
Total per Year	1[illegible]	20	60	60	100	100	100	100	100	100	100	100	100	100	100	1,250
Additional Azimuth Systems to be Acquired for Back Azimuth																
Basic I	1	2	4	4	8	8	8	8	8	8	8	8	8	8	8	99
SCMLS	1	1	2	2	4	4	4	4	4	4	4	4	4	4	4	50

Table 6-14 shows the LCC results of using this implementation strategy with the unit acquisition costs developed in Chapter Three and the installation costs developed in Chapter Four. Table 6-15 illustrates the cumulative logistic support costs, Table 6-16 shows the cumulative labor costs, and Table 6-17 illustrates the expected annual maintenance costs for the 1,250-system implementation plan. The acquisition, installation, and nonrecurring logistics costs of the new plan are similar to those of the basic analysis in Chapter Five, because a similar number of systems would be purchased. The recurring logistics costs are similar to the 15-year implementation plan of Section 6.4.2. The cumulative LCC is illustrated in Figure 6-4.

6.5 PRODUCTION SCHEDULES FOR MLS EQUIPMENTS

Production schedules for MLS equipments are particularly important when implementation strategies are being considered. A rapid implementation schedule may require that similar systems be produced by more than one manufacturer. This would occur if implementation schedule requirements exceeded the capacity of a single manufacturer to produce a particular MLS configuration.

To investigate the ramifications of this, we analyzed and interpolated the data generated during the course of this study. Since the Basic configuration data were developed for three different configurations in each production run, we looked at the SCMLS data so that we could directly compare single systems. We used the acquisition cost data from the 75-system SCMLS production run to represent two manufacturers producing a configuration similar to their own designs based on a performance specification. We compared those LCC results to data based on the 145-system SCMLS acquisition cost. These data represented one manufacturer with the production capacity approximately equal to the first two.

We assumed that, although the two systems are different, they have the same number of components with similar MTBFs. This assumption implied that the techniques are the same and that all components are similar but not identical (e.g., board layouts may be different, and waveguide elements radiating slots may be cut at different angles). This assumption also allowed us to use the existing acquisition data base. The results of the LCC comparison are shown in Table 6-18. Total SCMLS acquisition was from the Basic implementation strategy.

As Table 6-18 illustrates, the combined acquisition cost of systems obtained from two manufacturers exceeds that of systems obtained from one manufacturer by $6.9 million, or 7.7 percent. This is expected because of the higher acquisition costs associated with smaller production runs. (Unit system costs would be $203,300 for a 75-unit production run and $188,800 for a 145-unit production run.) Acquisition costs in Table 6-18 include the 3 percent factory inspection cost.

Total installation costs shown in Table 6-18 are the same for each manufacturing method, because installation costs are independent of manufacturing costs, assuming that the installations are similar.

Table 6-14. LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, 1,250-SYSTEM BUY

Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS	SCMLS Back Azimuth	Basic I	Basic I Back Azimuth	Basic II	Expanded	
Acquisition	93.289	3.510	183.365	15.473	110.928	40.968	447.533
Installation	94.717	0.690	128.117	2.485	52.340	21.949	300.298
Nonrecurring Logistics	24.987	2.393	23.687	2.931	21.553	18.847	94.398
Recurring Logistics	90.768	5.284	164.039	17.031	106.022	51.044	434.188
Total	303.761	11.877	499.208	37.920	290.843	132.808	1,276.417

Table 6-15. CUMULATIVE LOGISTIC SUPPORT COSTS FOR 1,250 MLS GROUND SYSTEMS

Cost Category	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS	SCMLS Back Azimuth	Basic I	Basic I Back Azimuth	Basic II	Expanded	
Nonrecurring Costs							
Spares	7.895	2.139	13.623	2.583	12.372	10.438	49.050
Inventory Management	0.036	0.000	0.037	0.000	0.037	0.037	0.147
Support Equipment	0.190	0.190	0.090	0.090	0.098	0.090	0.748
Training	0.698	0.036	1.260	0.132	0.828	0.301	3.255
Data Management	15.720	0.000	7.860	0.000	7.860	7.860	39.300
Transportation	0.448	0.028	0.817	0.126	0.358	0.121	1.898
Total	24.987	2.393	23.687	2.931	21.553	18.847	94.398
Recurring Costs							
Spares	32.594	3.102	71.734	9.599	49.170	28.583	194.782
On-Site Maintenance	28.158	1.525	50.067	5.418	32.414	11.618	129.200
Off-Site Maintenance	15.391	0.373	24.450	1.362	11.198	3.834	56.608
Inventory Management	0.104	0.000	0.107	0.000	0.098	0.098	0.407
Support Equipment	0.012	0.000	0.043	0.002	0.046	0.018	0.121
Training	1.041	0.055	1.880	0.198	1.222	0.435	4.831
Data Management	7.176	0.000	2.153	0.000	1.966	1.966	13.261
Facilities	1.794	0.000	1.794	0.000	1.638	1.638	6.864
Site Operations	4.498	0.229	11.811	0.452	8.270	2.854	28.114
Total	90.768	5.284	164.039	17.031	106.022	51.044	434.188

Table 6-16. CUMULATIVE LABOR COSTS FOR MLS GROUND SYSTEMS WITH 1,200-SYSTEM DEPLOYMENT

Labor Category	Cost by System Type (Millions of Constant 1980 Dollars)						Total
	SCMLS	SCMLS Back Azimuth	Basic I	Basic I Back Azimuth	Basic II	Expanded	
Corrective Maintenance	22.728	0.968	42.174	4.221	27.784	9.893	107.768
Preventive Maintenance	2.147	0.397	2.158	0.590	0.973	0.439	6.704
Base-Level Repair	3.505	0.145	9.444	0.861	6.655	2.177	22.787
Depot-Level Repair	0.218	0.009	0.585	0.053	0.412	0.135	1.412
Total	28.598	1.519	54.361	5.725	35.824	12.644	138.671

Table 6-17. EXPECTED ANNUAL MAINTENANCE COSTS WITH 1,200-SYSTEM DEPLOYMENT

Labor Category	Cost by System Type (Millions of Constant 1980 Dollars)												Total	
	SCMLS		SCMLS Back Azimuth		Basic I		Basic I Back Azimuth		Basic II		Expanded			
	Hours*	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost
Corrective Maintenance	104.7	1.526	4.4	0.065	194.0	2.829	19.5	0.284	129.2	1.884	47.1	0.687	498.9	7.275
Preventive Maintenance	9.0	0.140	0.9	0.022	9.0	0.140	1.8	0.035	3.7	0.062	1.2	0.027	25.6	0.426
Base-Level Repair	13.5	0.236	0.6	0.010	36.4	0.634	3.3	0.058	25.9	0.452	8.7	0.152	88.4	1.542
Depot-Level Repair	0.7	0.015	0.0	0.001	1.9	0.039	0.2	0.004	1.4	0.028	0.5	0.009	4.7	0.096
Total	127.9	1.917	5.9	0.098	241.3	3.642	24.8	0.381	160.2	2.426	57.5	0.875	617.6	9.339

*Thousands of hours.

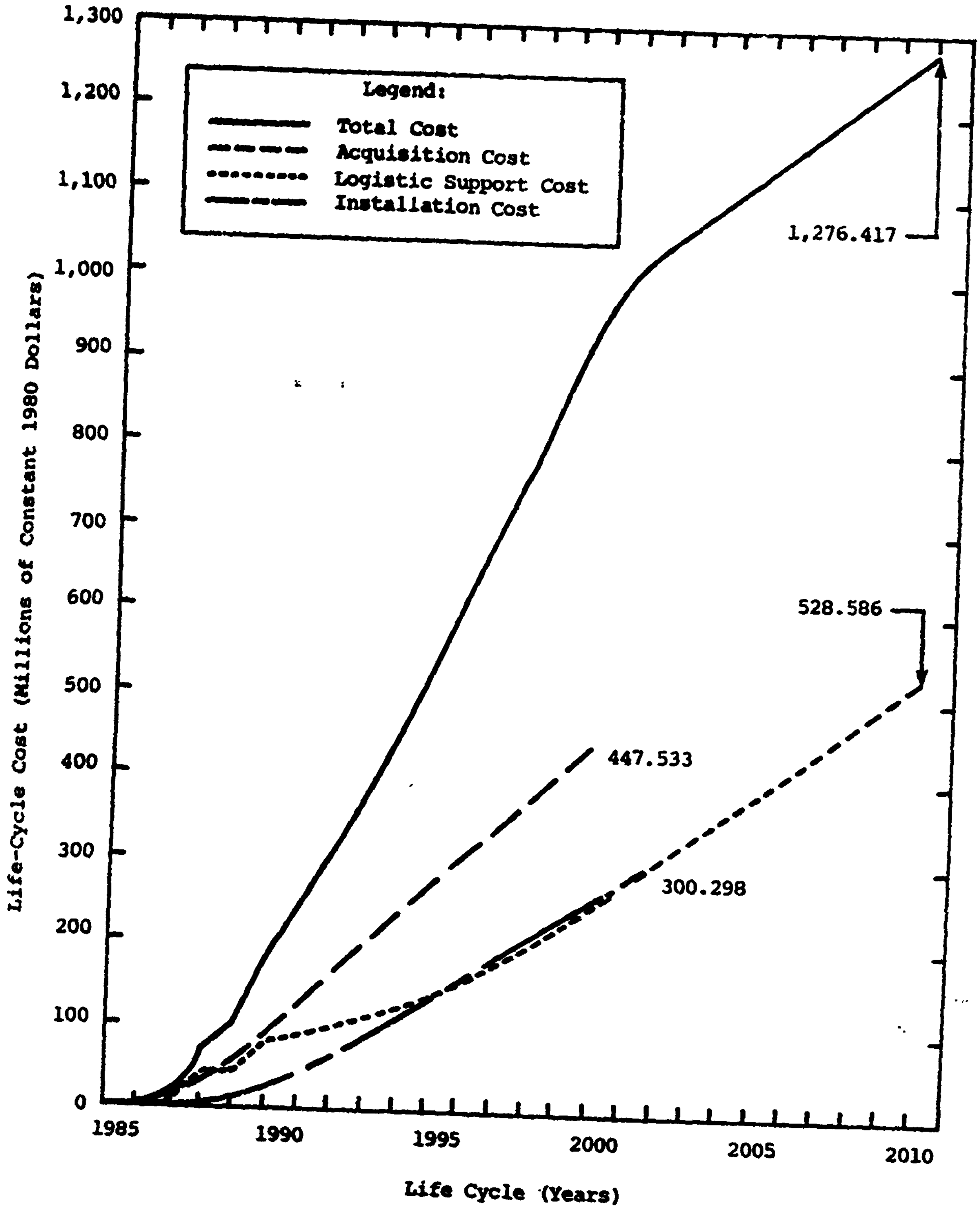

Figure 6-4. CUMULATIVE LIFE-CYCLE COST -- 1,250-SYSTEM IMPLEMENTATION

Table 6-18. LIFE-CYCLE-COST COMPARISON BETWEEN SINGLE MANUFACTURER AND DUAL MANUFACTURERS OF SCMLS EQUIPMENT				
Cost Category	Costs (Millions of Constant 1980 Dollars)			
	Single Manufacturer* (463 Systems)	Dual Manufacturers**		
		Manufacturer "A" (231 Systems)	Manufacturer "B" (232 Systems)	Total (463 Systems)
Acquisition	90.037	48.371	48.581	96.952
Installation	89.498	44.652	44.846	89.498
Nonrecurring Logistics	24.882	25.407	25.407	50.814
Recurring Logistics	84.865	65.202	65.302	130.504
Total	289.282	183.632	184.136	367.768

*Based on a production rate of 145 SCMLS systems over three years.
**Based on a production rate of 75 SCMLS systems over three years.

The nonrecurring logistics cost for the dual manufacturers is double that of the single manufacturer, because it was assumed that the designs would produce a completely different set of initial spares due to different card layouts and design techniques. These different designs would also create different maintenance manuals, the costs of which would appear in the nonrecurring costs.

The recurring logistics costs for each of the dual-manufacturer systems are about 77 percent of those for the single-manufacturer system. This is because the maintenance costs, facilities costs, and site operations costs are divided between the two systems. However, the other recurring cost factors are considered to be unique to each system. Table 6-19 shows both nonrecurring and recurring logistic support costs. Again, the major cost drivers are recurring spares and data costs. The table also shows that the total combined recurring logistic support costs of the dual manufacturers are approximately 54 percent greater than those for a single manufacturer. Overall acquisition through dual manufacturers would increase the LCC over that for a single manufacturer by 27 percent.

Table 6-19. CUMULATIVE LOGISTIC SUPPORT COST COMPARISON BETWEEN SINGLE MANUFACTURER AND DUAL MANUFACTURERS OF SCMLS EQUIPMENT

Cost Category	Costs (Millions of Constant 1980 Dollars)			
	Single Manufacturer* (463 Systems)	Dual Manufacturers**		
		Manufacturer "A" (231 Systems)	Manufacturer "B" (232 Systems)	Total (463 Systems)
Nonrecurring Costs				
Spares	7.852	8.589	8.589	17.178
Inventory Management	0.036	0.036	0.036	0.072
Support Equipment	0.190	0.190	0.190	0.380
Training	0.660	0.660	0.660	1.320
Data Management	15.720	15.720	15.720	31.440
Transportation	0.424	0.212	0.212	0.424
Total	24.882	25.407	25.407	50.814
Recurring Costs				
Spares	30.385	33.885	33.885	67.770
On-Site Maintenance	26.056	13.000	13.056	26.056
Off-Site Maintenance	14.220	7.095	7.125	14.220
Inventory Management	0.104	0.104	0.104	0.208
Support Equipment	0.011	0.011	0.011	0.022
Training	0.963	0.963	0.963	1.926
Data Management	7.176	7.176	7.176	14.352
Facilities	1.794	0.895	0.899	1.794
Site Operation	4.156	2.073	2.083	4.156
Total	84.865	65.202	65.302	130.504

*Based on a production rate of 145 SCMLS systems over three years.
**Based on a production rate of 75 SCMLS systems over three years.

CHAPTER SEVEN

MLS AVIONICS CONFIGURATIONS ACQUISITION COSTS

Development and production costs of MLS avionics were identified for the three user communities in general aviation -- commercial air carrier, high-performance general aviation aircraft, and low-performance general aviation aircraft. High-performance general aviation consists of turbojets, turboprops, and pressurized multi-engine aircraft. Low-performance general aviation consists of all other multi-engine piston, single-engine piston, and rotary wing aircraft.

7.1 SYSTEM CONFIGURATIONS

7.1.1 General

Table 7-1 lists the avionics costed. The required displays and DME costs were taken from available commercial products. In accordance with the objectives and assumptions of the MLS LCC study program plan, we did not consider the cost of modifying or purchasing on-board computers and modifying autopilots to take full advantage of MLS capabilities.

7.1.2 Production Avionics

Three prototype models of avionics have been developed through Government sponsorship. Air carrier and high-performance aircraft MLS avionics were developed for the FAA by Bendix Avionics Division. American Electronic Laboratories, Inc., and NARCO Avionics developed a low-performance aircraft avionics set through the sponsorship of NASA Ames. Design features and capabilities of those avionics were available for study. A new set of avionics was being developed for the Service Test Evaluation Program (STEP), but the equipments were not available during the course of this study.

7.1.2.1 Commerical Air Carrier MLS Avionics

The commercial air carrier MLS avionics were based on the prototype Bendix Avionics air carrier quality avionics. The units costed were an angle receiver-processor, with an ac/dc power supply and a built-in test (BIT) capability; an MLS control pannel; and an auxiliary data display. All units were assumed to be manufactured to ARINC characteristics. Costs were assumed for a precision DME, C-band antenna, and computer interface. Any required display was assumed to be existing.

Table 7-1. MLS AVIONICS CONSIDERED			
Considerations	Commercial Air Carrier Avionics	High-Performance General Aviation Avionics	Low-Performance General Aviation Avionics
Costs Determined by Study	Receiver-Processor Control Panel Auxiliary Data Display	Receiver-Processor Control Panel	Receiver-Processor C-Band Antenna
Commercial Costs Assumed	Precision DME C-Band Antenna Computer Interface	C-Band Antenna	None
Commercial Costs Used	None	CDI Display Conventional DME L-Band Antenna	CDI Display
Equipment Assumed to Exist and Not Costed	Display Conventional DME L-Band Antenna	None	None

7.1.2.2 High-Performance General Aviation Aircraft MLS Avionics

The high-performance general aviation (GA) aircraft MLS avionics were based on the SCMLS avionics manuals developed by Bendix Avionics. The receiver-processor was assumed to be similar to that of the air carrier aircraft, but with no BIT capability and no ac power supply. We developed the costs for this receiver by using lower quality parts to reduce the cost. The control panel was considered to be similar to the air carrier version. No auxiliary data display was included for this configuration. Costs for the CDI display, DME, and L-band antenna were based on existing commercially available equipment.

7.1.2.3 Low-Performance General Aviation Aircraft MLS Avionics

The low-performance GA aircraft MLS avionics were based on the NASA Ames-sponsored low-cost MLS avionics. These avionics consisted of an MLS receiver-processor with an integrated control panel and a remote microwave RF head integrated into the C-band antenna housing. A low-cost commercially available CDI display was included in the total installation.

7.2 ACQUISITION COSTS

7.2.1 General

The costs for all three types of avionics were developed under the same procedure used in developing the ground system costs. Features, capabilities, and component parts of the prototype receivers and peripheral equipments were identified by inspection of the receivers, consultation with the manufacturers, and review of the available documentation.

All manufacturing costs associated with the MLS avionics were developed with the assistance of a commercially available pricing model. Data were prepared on module, subassembly, and system levels to permit identification of costs drivers and application to the subsequent LCC analyses.

Tables 7-2 through 7-12 summarize the PRICE outputs by subassembly cost for development and production and show cumulative costs for the various classes of MLS avionics. The tables appear in the following subsections, according to the particular subassembly represented. We assumed production quantities over a three-year period of 1,500 units for air carrier avionics and 3,000 units for general aviation avionics on the basis of the expected implementation scenarios discussed in Chapter Eight. These quantities were considered to be sufficient to develop typical avionics production learning curves and to amortize development and start-up costs. All results are presented in constant 1980 dollars.

In each table, the last equipment entry, Test and Integration, is a mandatory input when a system is developed by subassemblies. Test and integration accounts for the final assembly of a unit, machining of interface components, provisioning of power connections, alignment and tuning of electrical subsystems, and performance of the final functional test of the system. The factory sell price represents the cost of manufacturing with appropriate G&A and profit included; it is the expected selling price to air carriers and distributors. The list price represents the normal cost to owners of private aircraft buying limited quantities of general aviation aircraft products.

7.2.2 MLS Avionics Cost Development for Air Carrier Aircraft

The unit costs of MLS avionics required by air carriers for implementation of the MLS are shown in Tables 7-2 (receiver), 7-3 (control panel), and 7-4 (auxiliary data display).

7.2.2.1 Angle Receiver

The MLS angle receiver consists of 13 subassemblies, the front panel, and the chassis enclosure. Table 7-2 summarizes the PRICE outputs by subassembly cost for development and production and gives the total cost. The costs are based on a 1,500-unit production run. There is no distributor markup for air carrier avionics, because the airlines buy directly from the manufacturer.

7.2.2.2 Control Panel

The MLS control panel consists of a power supply and a digital PCB, as well as the front panel and the chassis and enclosure. Table 7-3 lists the results of the PRICE outputs.

Table 7-2. MLS RECEIVER COSTS FOR AIR CARRIER AIRCRAFT			
Subassembly	Costs (1980 Dollars per Unit)		
	Development	Production	Total
Envelope Processor PCB	87	783	870
Digital Processor PCB	104	773	877
Input/Output PCB	48	803	851
AC Power PCB	29	402	431
DC Power PCB	25	344	369
Annunciator PCB	66	320	386
Synthesizer Control PCB	79	374	453
Synthesizer Harmonic Generator PCB	54	202	256
Synthesizer Microwave PCB	113	873	986
Front-End Module	36	479	515
RF Module	73	759	832
Test Generator Module	28	158	186
Interconnect PCB	61	353	414
Front Panel	6	134	140
Chassis and Enclosure	10	856	866
Integration and Test	23	425	448
Factory Sell Price			8,880
Distributor Markup			0
List Price			8,880

7.2.2.3 Auxiliary Data Display

The MLS auxiliary data display consists of a power supply, four additional subassemblies, the front panel, and the chassis and enclosure. Table 7-4 lists the results of the PRICE outputs.

7.2.2.4 Cost Summary

Costs of the avionics required by air carrier aircraft for implementation of the MLS are listed in Table 7-5. The costs shown are the total cost of development for each piece of avionics and the production costs per unit of the equipment as computed by the PRICE model. The Total column gives the

Table 7-3. MLS CONTROL PANEL COSTS FOR AIR CARRIER AIRCRAFT			
Subassembly	Costs (1980 Dollars per Unit)		
	Development	Production	Total
Power Supply PCB	56	322	378
Digital PCB	48	267	315
Front Panel	2	35	37
Chassis and Enclosure	8	247	255
Integration and Test	5	36	41
Factory Sell Price			1,026
Distributor Markup			0
List Price			1,026

Table 7-4. MLS AUXILIARY DATA DISPLAY COSTS FOR AIR CARRIER AIRCRAFT			
Subassembly	Costs (1980 Dollars per Unit)		
	Development	Production	Total
Binary BCD PCB	72	466	538
Data Control PCB	67	427	494
Display Electronics PCB	68	521	589
Power Supply	32	209	241
Display PCB	50	222	272
Front Panel	4	45	49
Chassis and Enclosure	8	247	255
Integration and Test	9	92	101
Factory Sell Price			2,539
Distributor Markup			0
List Price			2,539

Table 7-5. MLS AVIONICS COSTS FOR AIR CARRIER AIRCRAFT, SINGLE SYSTEM			
Equipment	Costs		
	Development* (1980 Dollars)	Production (1980 Dollars per Unit)	Total (1980 Dollars per Unit)
Receiver	1,261,564	8,038	8,880
Control Panel	177,070	907	1,026
Auxiliary Data Display	464,326	2,229	2,539
Total	1,902,960	11,174	12,445
Factory Sell Price			12,445
Distributor Markup			0
List Price			12,445

*Development costs are assumed to be amortized over a 1,500-unit production quantity.

production and development costs amortized over 1,500 units of production. The development costs are for any production quantity; the production costs, however, vary with the production quantity. The costs listed in Table 7-5 disagree slightly with those in Tables 7-2, 7-3, and 7-4 because the numbers have been rounded.

7.2.2.5 Air Carrier MLS Installation

A complete air carrier MLS installation requires peripheral equipment other than the avionics shown in Table 7-5 to allow MLS operation. The other equipments include antennas, displays DMEs, and computers if a full curved-approach capability is desired. We did not compute these costs through PRICE, but took commercially available equipments as required. We did not include the cost of a display for the air carrier installation, because aircraft currently have displays installed that can be used with the MLS. Display interface costs are included in the installation costs discussed in Chapter Eight. L-band DME costs are not included, because these are also currently in place on the aircraft. We did include one precision DME, assuming that there would be a one-for-one swap-out with a conventional DME. We also included a $1,500 cost for a computer interface. This cost was taken from Radio Technical Commission on Aeronautics (RTCA) Document DO-166 of July 1977, *Microwave Landing System Implementation*. The quantities and costs of equipment for the MLS installation are shown in Table 7-6.

Table 7-6. AIR CARRIER AVIONICS COST PER MLS INSTALLATION, BASED ON 500 UNITS PER YEAR (1980 DOLLARS)			
Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	2	8,880	17,760
MLS Control Panel	2	1,026	2,052
MLS Auxiliary Data Display	1	2,539	2,539
C-Band Antenna	2	150	300
Precision DME	1	11,385	11,385
Computer Interface	1	1,500	1,500
Total			35,536

7.2.3 MLS Avionics Cost Development for High-Performance GA Aircraft

The MLS avionics required for high-performance GA aircraft are an angle receiver and a control panel.

7.2.3.1 Angle Receiver

The MLS angle receiver is very similar to that for air carrier aircraft. The major difference is that the high-performance GA aircraft receiver has dc power only, and there is no BIT capability. This allows elimination of the ac power, annunciator, and test generator subassemblies. In addition, the GA receiver uses components of a lesser quality than does the air carrier receiver. This results in a decrease in cost and a slight decrease in MTBF on a per-PCB basis for the GA receiver. The envelope processor PCB for the high-performance GA receiver has an MTBF of 24,296 hours, compared with 25,287 hours for the air carrier receiver. Overall, the air carrier receiver MTBF of 1,430 is lower than the GA receiver MTBF of 1,702 hours, because the GA receiver has fewer subassemblies.

The high-performance GA angle receiver consists of 10 subassemblies, the front panel, and the chassis and enclosure. Table 7-7 summarizes the PRICE outputs by subassembly cost for development and production and gives the total cost. The costs are based on a 3,000-unit production run. The factory sell price is the cost to a distributor. The list price includes a markup for distribution and is the expected cost to single-aircraft owners requiring high-performance GA aircraft avionics.

7.2.3.2 Control Panel

The MLS control panel is similar to the air carrier control panel; the major difference is that lower quality parts are used. (Lower quality may be taken to mean plastic rather than ceramic parts.) Table 7-8 lists the

Table 7-7. MLS RECEIVER COSTS FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT			
Subassembly	Costs (1980 Dollars per Unit)		
	Development	Production	Total
Envelope Processor PCB	40	561	601
Digital Processor PCB	49	554	603
Input/Output PCB	23	575	598
DC Power PCB	12	248	260
Synthesizer Control PCB	38	268	306
Synthesizer Harmonic Generator PCB	26	145	171
Synthesizer Microwave PCB	54	628	682
Front-End Module	17	344	361
RF Module	35	545	580
Interconnect PCB	31	303	334
Front Panel	3	98	101
Chassis and Enclosure	4	620	624
Integration and Test	11	321	332
Factory Sell Price			5,553
Distributor Markup (30 percent)			1,666
List Price			7,219

results of the PRICE outputs for a 3,000-unit production run with a distributor markup of 30 percent.

7.2.3.3 Cost Summary

Costs of the MLS avionics required for high-performance GA aircraft are listed in Table 7-9. As with the air carrier versions, the costs shown are the total cost of development and the production costs per unit as computed by PRICE.

7.2.3.4 High-Performance GA MLS Installation

An MLS receiver and control panel are only part of the MLS installation in a high-performance GA aircraft. We assumed for the LCC portion of this study that a complete MLS installation includes a conventional DME, an L-band antenna, and a display, in addition to the MLS receiver, control panel, and C-band antenna. Table 7-10 shows the quantities and costs of equipment used in the LCC study.

Table 7-8. MLS CONTROL PANEL COSTS FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT			
Subassembly	Costs (1980 Dollars per Unit)		
	Development	Production	Total
Power Supply PCB	27	231	258
Digital PCB	23	191	214
Front Panel	1	25	26
Chassis and Enclosure	4	180	184
Integration and Test	2	26	28
Factory Sell Price			710
Distributor Markup (30 percent)			213
List Price			923

Table 7-9. MLS AVIONICS COSTS FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT			
Equipment	Costs		
	Development* (1980 Dollars)	Production (1980 Dollars per Unit)	Total (1980 Dollars per Unit)
Receiver	1,025,695	5,210	5,553
Control Panel	167,657	653	710
Total	1,193,352	5,863	6,263
Factory Sell Price			6,263
Distributor Markup (30 percent)			1,879
List Price			8,142

*Development costs are assumed to be amortized over a 3,000-unit production quantity.

Table 7-10. HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT AVIONICS COST PER MLS INSTALLATION, BASED ON 1,000 UNITS PER YEAR (1980 DOLLARS)			
Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	1	7,219	7,219
MLS Control Panel	1	923	923
C-Band Antenna	1	195	195
L-Band Antenna	1	117	117
Conventional DME	1	5,850	5,850
CDI Display	1	916	916
Total			15,220

7.2.4 MLS Avionics Cost Development for Low-Performance GA Aircraft

The MLS avionics for low-performance GA aircraft are a receiver with an integrated panel and an antenna.

7.2.4.1 Angle Receiver

The MLS angle receiver is the low-cost airborne MLS receiver developed for NASA Ames by American Electronic Laboratories, Inc., and NARCO Avionics. The receiver utilizes four subassemblies, including the power supply. All controls are integrated into the front panel of the receiver and consist of on/off, volume, and ident controls; a channel-selection capability; and a glide-slope-select switch. Table 7-11 summarizes the PRICE outputs by subassembly cost for development and production and gives the total cost. The costs are based on a 3,000-unit production run. The 100 percent markup for distribution is the normal markup for low-performance GA aircraft avionics.

7.2.4.2 Antenna

The MLS antenna developed for the low-performance GA aircraft incorporates a remote RF head to minimize the expected antenna cable losses. After disassembling the antenna and reviewing the design and construction, we priced the assembly as one unit. The antenna cost is shown in Table 7-12.

7.2.4.3 Cost Summary

Costs of the MLS avionics required for low-performance GA aircraft are shown in Table 7-12. The cost factors shown are the total cost of development and the production costs per unit as computed by PRICE.

Table 7-11. MLS RECEIVER COSTS FOR LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT

Subassembly	Costs (1980 Dollars per Unit)		
	Development	Production	Total
Synthesizer PCB	28	197	225
IF/Detector PCB	19	111	130
Processor PCB	33	130	163
Power Supply	17	83	100
Front Panel	3	22	25
Enclosure and Chassis	1	56	57
Integration and Test	13	111	124
Total	114	710	824
Factory Sell Price			824
Distributor Markup (100 percent)			824
List Price			1,648

Table 7-12. MLS AVIONICS COSTS FOR LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT

Equipment	Costs		
	Development* (1980 Dollars)	Production (1980 Dollars per Unit)	Total (1980 Dollars per Unit)
Receiver	341,876	710	824
Antenna	63,788	152	173
Total	405,664	862	997
Factory Sell Price			997
Distributor Markup (100 percent)			997
List Price			1,994

*Development costs are assumed to be amortized over a 3,000-unit production quantity.

7.2.4.4 Low-Performance GA Aircraft Installation

We assumed for the LCC portion of this study that a complete MLS installation for minimum capability consists of an angle receiver, antenna, and CDI display. Table 7-13 shows the quantities and costs of equipment used in the LCC study.

Table 7-13. LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT AVIONICS COST PER MLS INSTALLATION, BASED ON 1,000 UNITS PER YEAR (1980 DOLLARS)

Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	1	1,648	1,648
C-Band Antenna	1	346	346
CDI Display	1	600	600
Total			2,594

CHAPTER EIGHT

AIRBORNE LIFE-CYCLE-COST MODEL COMMON PARAMETERS

This chapter addresses the development of data items that were treated in the economic analysis as being common to any MLS concept. These items include the estimated installation costs of MLS avionics and population projections for the civil aviation community.

8.1 COST OF MLS AVIONICS

The costs of the various MLS avionics configurations that may be implemented in the civil aviation community were discussed in Chapter Seven. It was assumed that the MLS avionics would have a unique configuration for each of the three classes of aircraft.

8.2 AIRCRAFT CONFIGURATION

The complement of equipment to be installed by a user usually depends on individual needs, probable flight profiles, the reliabilities required to provide suitable aircraft availability, and the anticipated or required flight crews for special classes of aircraft. For this study, we assumed that air carriers would carry dual MLS avionics, while high- and low-performance general aviation aircraft would carry one set of MLS avionics, as discussed in Chapter Seven.

8.3 INSTALLATION COSTS

The costs of avionics installations considered in this study came under two categories -- retrofit of the existing fleet, and installation in new aircraft. These installation costs were segregated into the three aircraft classes of commercial air carrier, high-performance general aviation, and low-performance general aviation. Avionics retrofit installation costs for all three aircraft classes was developed from data in FAA Report EM-79-14 of November 1979, *Development of Avionics Retrofit Installation Costs in Air Carrier and General Aviation Aircraft*.

8.3.1 Commercial Air Carrier Installation Costs

Installation costs for commercial air carriers were based on the installation costs required for the Ground Proximity Warning System (GPWS) and the Omega Navigation System (ONS). These systems were chosen because substantial data were available from each to compute costs. The GPWS was also chosen because it was retrofitted in all commercial air carriers; an advantage of using the ONS was that it is a more complex installation than the GPWS.

The GPWS consists of a single rack-mounted computer unit within the electronics bay of an aircraft. The unit accepts inputs from various aircraft sensors to determine terrain proximity. To retrofit this system in the aircraft, the cockpit must be modified for installation of the warning lights and speaker. The computer is installed in the electronics bay, with appropriate cabling to sensors and the cockpit warning devices.

The ONS consists of three units -- a rack-mounted receiver-processor located in the electronics bay, a cockpit control and display unit, and a remotely located antenna and antenna coupler unit. The receiver-processor houses the main electronic circuitry for processing sensor inputs to compute aircraft location. The control-display unit provides a means for manually inserting system control data and selecting modes of operation. It also provides read-out capability for receiver-processor navigation data. The antenna coupler unit senses Omega radio signals and couples them to the receiver circuits by suitable cabling.

Installation of the ONS requires modification of the cockpit for the control-display unit, a space in the electronics bay for the receiver-processor, modification to the aircraft outer skin for the antenna, and integration with other aircraft systems requiring navigation data inputs. Most air carriers have dual Omega systems that consist of two control-display and receiver-processor units but only a single antenna.

Since installation of the GPWS is probably less complex than an MLS installation, while the ONS is more complex, we developed a weighted average between these two costs to reflect the expected MLS installation costs. Since we were dealing with a dual installation, the average was weighted 2 to 1 in favor of the ONS average cost. Table 8-1 shows the expected labor hours and material cost of retrofitting avionics in air carrier aircraft, using the 1980 labor rate and cost of materials. The installation hours account for both shop prefabrication labor and on-aircraft labor for installing shelves, control panels, wiring, and avionics. Material cost accounts for all material other than prime electronics consumed during the installation. Cable, fasteners, hardware shelves, and circuit breakers are included and accounted for in this cost category. We updated the labor and material costs from FAA Report EM-79-14 by using a Bureau of Labor Statistics inflation factor of 9.23 percent to arrive at a new base labor rate of $30.29 per hour. It was assumed that installation costs in new air carrier aircraft would be 60 percent of the estimated retrofit cost of $1,560 for a complete installation, or $6,940.

Table 8-1. AVIONICS RETROFIT INSTALLATION HOURS AND COSTS FOR AIR CARRIER AIRCRAFT				
Cost Category	Stand-Alone System		Integrated System	
	Hours	Cost*	Hours	Cost*
Installation Hours	166	5,028	357	10,813
Engineering Hours	7	212	19	575
Material Dollars	--	791	--	2,933
Total Installation Cost	--	6,031	--	14,321
Weighted Average Retrofit Installation Cost = $11,560				
*1980 dollars at $30.29 per hour.				

8.3.2 General Aviation Aircraft Installation Costs

High-performance aircraft in this user category include a variety of twin-engine executive jets, pressurized twin-engine turboprop aircraft, and some multi-engine piston aircraft. These aircraft usually use avionics that resemble ARINC-characteristic equipment but are manufactured in "dwarf" sizes. However, ARINC-characteristic avionics are also frequently found in the avionics configurations of these aircraft. Low-performance aircraft include single-engine and light twin-engine aircraft.

Although no single piece of avionics has a widespread retrofit program for general aviation aircraft, data were available for a number of systems, so an average installation rate could be computed.

8.3.2.1 High-Performance General Aviation Aircraft

Avionics systems considered in FAA Report EM-79-14 for high-performance GA aircraft are grouped into two categories -- (1) a "stand-alone" system, which includes any avionics that require an antenna, electronic unit, and control or display, and (2) an "integrated" system, which, in addition to the basic equipment, usually includes considerable interface with other on-board avionics such as flight computers, autopilots, or DME. Typical stand-alone systems are the VHF communication system and the ATC transponders. Integrated systems include the area navigation system (R-NAV) and the inertial navigation system (INS).

High-performance GA aircraft avionics are categorized not only by the stand-alone or integrated nomenclature, but also by the category of aircraft executive jet or executive turboprop. The reason for this is that the airframes of turboprop aircraft are more easily accessible and rewired;

therefore, installation time is considerably less. For executive jets, installation time includes removal and reinstallation of interiors often associated with avionics additions because of the location of new avionics, cableways, and antennas.

Table 8-2 shows the expected labor hours and material cost of retrofitting avionics in high-performance GA aircraft. The costs were updated from FAA Report EM-79-14 by using a Bureau of Labor Statistics inflation factor of 9.23 percent to arrive at a new base labor rate of $28.40 per hour. Engineering includes design of the installation, documentation, and preparation of the material lists associated with the installation. Antenna installation labor includes the RF cable and assumes a new penetration in the lower fuselage of the aircraft. Wiring is normally installed on the aircraft with very limited shop harness fabrication, since most cables do not terminate in an electronics bay. Hours noted for certification include the clerical effort necessary to return the aircraft to flight status meeting the Government's airworthiness and safety standards. Material costs account for all materials consumed during the installation such as wires and fuses.

To determine the average MLS installation costs in high-performance GA aircraft, we assumed that 50 percent of the aircraft would use a nonintegrated MLS, or stand-alone system, and 50 percent would use MLS avionics fully integrated with the R-NAV system. Approximately 31 percent of turbojet and 44 percent of turboprop aircraft currently have R-NAV systems. We weighted this obtained average retrofit cost between the number of turbojet and turboprop aircraft (see Table 8-4). We included the high-performance multi-engine piston aircraft with turboprop aircraft. This resulted in an expected average retrofit cost of $9,770 for high-performance aircraft. It was assumed that installation costs in new aircraft would be 60 percent of the estimated retrofit cost of $9,770, or $5,860.

8.3.2.2 Low-Performance General Aviation Aircraft

Low-performance GA aircraft avionics, intended for the single-engine and light twin-engine aircraft, are usually of the stand-alone type and consist of an antenna and an electronics unit. The electronics unit, mounted in the flight console of the aircraft, has built-in control and display features and requires wiring for antenna input and aircraft power input.

Installation cost data for low-performance GA aircraft were developed on the basis of a survey of avionics maintenance facilities, because the majority of low-performance GA aircraft are maintained at such facilities throughout the country. In 1974, more than 500 maintenance facilities were surveyed for information on the labor requirement to retrofit a NARCO DME-190 unit with an appropriate antenna in the low-performance class of aircraft. The results of this survey were published in *Cost Analysis of Airborne Collision Avoidance Systems (CAS) Concepts,* FAA Report EM-76-1. In 1979, ARINC Research interviewed a selected sample of the responding maintenance organizations and obtained their new labor rates for comparison with those furnished in 1974. The labor estimates obtained in 1974 were in hours and are still considered valid. The new labor and material costs were

Table 8-2. AVIONICS RETROFIT INSTALLATION HOURS AND COSTS FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT				
Cost Category	Turbojet		Turboprop	
	Hours	Cost*	Hours	Cost*
Stand-Alone Systems				
Engineering	20	568	15	426
Antenna	50	1,420	25	710
Wiring	75	2,130	23	653
Installation	150	4,260	45	1,278
Certification	20	568	50	1,420
Material Dollars	--	275	--	275
Total Installation Cost	--	9,221	--	4,762
Integrated Systems				
Engineering	100	2,840	40	1,136
Antenna	50	1,420	30	852
Wiring	250	7,100	140	3,976
Installation	210	5,964	120	3,408
Certification	100	2,840	50	1,420
Material Dollars	--	550	--	275
Total Installation Cost	--	20,714	--	11,067
Average Installation Cost	--	14,968	--	7,915
Retrofit Costs Based on 2,500 Turbojet and 7,000 Turboprop and Piston Aircraft = $9,770				
*1980 dollars at $28.40 per hour.				

published in FAA Report EM-79-14. We updated these labor and material costs by using a Bureau of Labor Statistics inflation factor of 9.23 percent to arrive at a new base labor rate of $25.25 per hour. Table 8-3 shows the expected labor hours and material costs of retrofitting avionics in low-performance GA aircraft, using the 1980 labor rate and cost of materials.

Table 8-3. AVIONICS RETROFIT INSTALLATION HOURS AND COSTS FOR LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT				
Cost Category	Single-Engine Aircraft (166,000 Aircraft)		Twin-Engine Aircraft (19,300 Aircraft)	
	Hours*	Cost**	Hours*	Cost**
Electronics	4.51	113.88	6.43	162.36
Antenna	2.32	58.58	3.21	81.05
Cabling	3.92	98.98	5.31	54.35
Material	--	40.43	--	54.35
Total Installation Cost	--	311.87	--	431.84

*Based on the mean of labor hours quoted by 125 facilities.
**1980 dollars at $25.25 per hour.

For the purpose of this analysis, we used a weighted average of $325 for a complete installation in low-performance GA aircraft. It was assumed that installation costs in new low-performance GA aircraft would be 60 percent of the estimated retrofit cost of $325, or $195.

8.4 AIRCRAFT SCENARIO

Implementation of the MLS in aircraft is assumed to begin in 1989, based on MLS ground system deployment in 1987. The two-year period between MLS ground deployment and initial aircraft implementation allows for the installation of approximately 140 ground systems. With a continual ground system implementation, this should offer an adequate incentive for operators to install the MLS in their aircraft.

To develop an aircraft baseline for 1989 and project an expected installation schedule for the MLS, we reviewed a number of documents. Among these were FAA Report AVP-80-8 of September 1980, *FAA Aviation Forecasts FY 1981-1992;* FAA Report AVP-79-9 of September 1979, *FAA Aviation Forecasts FY 1980-1991;* FAA Report AVP-78-11 of September 1978, *FAA Aviation Forecasts FY 1979-1990;* FAA Report MS-79-5 of April 1979, *1977 General Aviation Activity and Avionics Survey;* FAA Report MS-80-5 of March 1980, *1978 General Aviation Activity and Avionics Survey; FAA Statistic Handbook of Aviation for 1978;* and *The World Aviation Directory,* Volumes 75 through 80. Our purpose was to balance projections with production quantities to determine an increment of new aircraft per year. Most forecasts deal only with actual total fleet increases per year without providing separate categories for the number of new aircraft per year and aircraft inactivated each year. Table 8-4 presents the baseline aircraft data as of 1 January 1979. This date was chosen because the data of FAA Report MS-80-5 and FAA Report AVP-80-8 for that date agreed. The table shows not only the baseline year, but the projected change in active aircraft population per year. The avionics survey allowed us to determine the percentages of aircraft with ILS, DME, R-NAV, or autopilots installed. These percentages were used to determine the probable number of MLSs installed per year. The extensive data base available in FAA Report MS-79-5 and FAA Report MS-80-5 led to the determination that approximately 17 percent of the multi-engine piston aircraft were in the high-performance category.

Table 8-4. BASELINE AIRCRAFT DATA

Aircraft Data Category	General Aviation Aircraft						Air Carrier Aircraft
	Low Performance			High Performance			
	Single Engine	Multi-Engine	Rotor Craft	Turbojet	Turboprop	Piston Multi-Engine	
Statistical Data as of 1 January 1979							
Active Aircraft	160,700	19,300	5,300	2,500	3,100	3,900	2,625
Average Flight Hours per Year	173	263	396	509	533	263	2,645
Percent with ILS Equipment	46.4	95.8	11.7	95.0	97.2	95.8	100.0
Percent with DME	16.3	81.1	5.2	93.4	95.0	81.1	100.0
Percent with R-NAV	3.6	26.5	2.6	30.5	44.0	26.5	100.0
Percent with Autopilot	19.1	79.4	0.8	91.0	84.4	79.4	100.0
Projected Data							
New Aircraft per Year	10,900	1,500	450	400	600	300	115
New Aircraft per Year with ILS	5,060	1,440	50	380	580	285	115
Aircraft Inactivated per Year	2,000	600	100	100	250	100	70
Aircraft Inactivated per Year with ILS	928	569	12	95	246	95	70
Aircraft Fleet Increase per Year	8,900	900	350	300	350	200	45

The data from Table 8-4 were combined with data from FAA Report AVP-80-8 to arrive at a projection of the expected active aircraft population. Table 8-5 uses the percentage of aircraft with ILS equipment to predict the average number of MLS installations added per year. It was assumed that all new GA aircraft that would implement the ILS beginning in 1989 would implement the MLS according to the following schedule:

- 1989 to 1990 -- 25 percent MLS equipage
- 1991 to 1992 -- 50 percent MSL equipage

Table 8-5. LIFE-CYCLE-COST BASELINE DATA BY AIRCRAFT CATEGORY			
Aircraft Data Category	General Aviation Aircraft		Air Carrier Aircraft
	Low Performance	High Performance	
Statistical Data as of 1 January 1979			
Active Aircraft	185,300	9,500	2,625
Aircraft Added per Year with ILS	6,550	1,245	115
Aircraft Fleet Increase per Year	10,150	850	45
Projected Data			
Active Aircraft	286,800	18,000	3,075
Average Flight Hours per Year per Aircraft	189	416	2,645
Active Aircraft with ILS	144,100	17,294	3,075
Average MLS Installations Added per Year	6,550	1,245	115
Average MLS Installations Retrofitted per Year	500*	500*	700**

*Constant throughout the LCC analysis.
**Four years only.

- 1993 to 1994 -- 75 percent MLS equipage
- 1995 to 2005 -- 100 percent MLS equipage

We also assumed that all new air carrier aircraft would be equipped with the MLS beginning in 1989. Using these two assumptions and the data of Table 8-5, we developed the installation schedule for the MLS avionics used for this LCC analysis. The schedule is shown in Table 8-6.

The MLS retrofit data in Table 8-5 for GA aircraft are based on the percentage of aircraft with R-NAV equipment. The reason for this is because the ILS will remain available for 20 years after MLS installation begins, and it was believed that the only GA aircraft that would be retrofitted with the MLS were those that had R-NAV capability. The number of sets retrofitted was assumed to be a constant 500 units per year throughout the LCC study for both high- and low-performance GA aircraft. It was assumed that the retrofit period for air carrier aircraft would be four years at a

Table 8-6. MLS AVIONICS INSTALLATION SCHEDULE						
Year	Number of Installations by MLS Avionics Class					
	Air Carrier		High-Performance General Aviation		Low-Performance General Aviation	
	New	Retrofit	New	Retrofit	New	Retrofit
1989	115	700	315	500	1,638	500
1990	115	700	315	500	1,638	500
1991	115	700	625	500	3,275	500
1992	115	700	625	500	3,275	500
1993	115	0	935	500	4,912	500
1994	115	0	935	500	4,912	500
1995	115	0	1,245	500	6,550	500
1996	115	0	1,245	500	6,550	500
1997	115	0	1,245	500	6,550	500
1998	115	0	1,245	500	6,550	500
1999	115	0	1,245	500	6,550	500
2000	115	0	1,245	500	6,550	500
2001	115	0	1,245	500	6,550	500
2002	115	0	1,245	500	6,550	500
2003	115	0	1,245	500	6,550	500
2004	115	0	1,245	500	6,550	500
2005	115	0	1,245	500	6,550	500
2006	115	0	1,245	500	6,550	500
2007	115	0	1,245	500	6,550	500
2008	115	0	1,245	500	6,550	500
2009	115	0	1,245	500	6,550	500
Total	2,415	2,800	22,425	10,500	117,900	10,500

constant 700 retrofits per year, and that all air carrier aircraft not scheduled for retirement within the first four years would be retrofitted with the MLS. The four-year retrofit period is based on historical data. The average number of flight hours per year per aircraft is a weighted average of all aircraft in a category.

On the basis of Table 8-5, we derived aircraft-particular parameters such as quantities, flight hours, and production schedules for the airborne portion of the LCC study. The table is based on current aircraft production rates, aircraft exports, and FAA projections.

8.5 MAINTENANCE SCENARIO

The maintenance scenario used in the LCCM considered two levels of repair -- on-aircraft and off-aircraft maintenance. On-aircraft maintenance consists of simple removal and replacement of failed units; off-aircraft maintenance encompasses all other maintenance actions required in the event of an equipment failure.

8.5.1 On-Aircraft Maintenance

On-aircraft maintenance cost is limited to the cost of removing and replacing a failed unit. Preventive maintenance was not considered.

Removal and replacement actions are initiated when an aircraft lands at a repair facility and reports an equipment failure. The cost incurred is for the time required to complete the maintenance action, charged on an hourly basis. For the purpose of this analysis, the time required was assumed to be 1.5 hours, broken down as follows:

- Fifteen minutes for the maintenance technician to get to the aircraft
- Fifteen minutes to remove the failed unit
- Fifteen minutes to take the failed unit back to the shop for testing and repair or replacement
- Fifteen minutes to return to the aircraft with the repaired or replacement unit
- Fifteen minutes to reinstall the unit in the aircraft
- Fifteen minutes for the maintenance technician to return to the shop

8.5.2 Off-Aircraft Maintenance

Off-aircraft maintenance costs are costs incurred during the actual repair of a failed module. These expenses include the costs of materials, labor, shipping, and failure documentation. It was assumed that air carrier aircraft avionics would be sent to a depot for repair, and that high- and low-performance GA aircraft avionics would be taken to an avionics repair shop.

Module repair at the avionics repair shop is restricted to bench testing, removing, and replacing the failed modules within the failed unit. Repair times are attributed to the unit and to each module. Since a minimum number of spares (e.g., one of each type) are inventoried at avionics repair shops, users may often have to wait for their repaired units to be returned. This waiting period is reflected in the avionics repair shop and depot pipeline (turnaround) times and order and shipping times for replacement modules.

It was assumed that, with the exception of the chassis, no modules would be repaired at the avionics shop. Rather, the failed modules would be shipped to a depot, or manufacturer, for repair.

Once the failed module arrives at the depot it is repaired or replaced, incurring both a materials cost and a labor cost. These costs are peculiar to the particular module being repaired. The maintenance action is then documented, and the repaired item is shipped back to the avionics repair shop, thus completing the off-aircraft maintenance cycle.

It was assumed that there would be 20 bases and 3 depots for air carriers in the first year of MLS implementation. This projection was based on the number of major and nonmajor air carriers currently operating and the probable number of manufacturers that might offer air carrier-quality MLS equipment. For general aviation aircraft, we assumed that initially there would be 25 avionics repair shops, increasing at a rate of 10 per year. The number of high-performance aircraft depots would increase from two the first year to a maximum of four, and low-performance aircraft depots would increase from two the first year to a maximum of eight over the life of the program. These assumptions were based on the expected limited implementation rate of the MLS in GA aircraft and the probable number of equipment manufacturers. Currently there are approximately eight manufacturers of complete lines of low-performance aircraft avionics and four manufacturers of high-performance aircraft avionics.

CHAPTER NINE

INDIVIDUAL AND FLEET COSTS FOR MLS AVIONICS IMPLEMENTATION

9.1 COST MODEL

To evaluate the economic impact of MLS avionics on the civil aviation community, ARINC Research Corporation adapted and updated its airborne EAM for this study.

The model has been programmed in FORTRAN IV+ for use with a Digital Equipment Corporation PDP-11/34 minicomputer. It computes the expected annual and cumulative acquisition, installation, and logistic support costs for each concept. Appendix G documents the program features and mathematical formulation of the EAM; Appendix H is a program listing of the EAM.

9.2 ADDITIONAL INPUTS REQUIRED BY THE MODEL

The data developed in Chapters Seven and Eight constitute only a portion of the data required to compare avionics or establish the cost of implementation. Many parameters contributing to the evaluation of the systems and LCCs are dictated by the civil aviation user community. These data were developed, as were other parameters required by the model, through research conducted by ARINC Research Corporation for this contract and others.

A complete list of the parameters influencing the LCC evaluation is presented in Appendix I to this report. All the parameters considered to be influential in evaluating the relative costs and reliabilities of the systems have been programmed into the cost model.

9.3 RESULTS OF APPLYING THE ECONOMIC ANALYSIS MODEL

The ARINC Research EAM computes annual and cumulative acquisition, installation, and logistic support costs for each concept and user combination desired. The model was programmed to print out data for 21 years to be consistent with the ground LCC study. Airborne implementation was assumed to have started four years after acquisition of the first ground system.

This section presents the results derived from the model on the basis of the parametric inputs provided. The results are presented on a per-aircraft basis to facilitate identifying separately the costs of acquisition, installation, nonrecurring logistics, and recurring logistics. The 21-year life-cycle costs expected by an aircraft owner in any of the user categories are also presented. The life-cycle costs of system implementation for each user community's total fleet of aircraft are shown in graphic format to illustrate the year-by-year cost of system implementation. During this analysis, we did not consider the expected life of the avionics or their possible replacement cost.

9.3.1 Cost of Ownership per Aircraft

The cost of ownership of MLS avionics on a per-aircraft basis consists of the initial acquisition and installation costs for equipment configurations (developed in Chapter Seven), a proportion of the nonrecurring logistic support costs (determined by averaging over the entire user population in the 21-year life cycle), the recurring logistic support costs attributed to an aircraft during the first year, and the cumulative life-cycle cost of aircraft maintenance during the 21 years. These costs can be combined to provide an evaluation of the system based on both initial investment and reliability.

Logistic support costs are divided into two categories -- nonrecurring costs associated with the introduction of a new system, and recurring costs experienced from normal corrective maintenance of the system. The cost categories are as follows:

- On-aircraft maintenance
- Off-aircraft maintenance
- Spare parts
- Inventory management
- Support equipment
- Training
- Technical data and failure documentation
- Facilities

All of these cost categories contribute to the recurring logistics costs, and all but on- and off-aircraft maintenance contribute to the nonrecurring logistics cost. For example, spare parts are normally purchased by a repair facility and introduced into the inventory system, resulting in costs associated with the spares and inventory setup, both of which are considered to be nonrecurring. Upon failure of a unit, spares are used and replacement spares are ordered, generating a recurring cost for parts and documentation. The EAM computes such costs on the basis of the probability of failures.

Logistic support costs on a per-aircraft basis for the GA community, however, are limited to the recurring costs of maintenance, i.e., on- and off-aircraft maintenance costs incurred in repairing a failed unit. We do not expect that the individual GA aircraft owner would stock either spare parts or test equipment and, consequently, directly incur the management or facility costs associated with maintaining an inventory. The repair facility inventory maintenance costs are reflected in the GA cumulative life-cycle costs, however, since the EAM includes all cost categories.

9.3.1.1 Commercial Aviation

Table 9-1 presents the costs of implementing the MLS on a per-aircraft basis. The table shows in 1980 dollars the acquisition, installation, and estimated portions of the nonrecurring and recurring logistic support costs to be incurred for MLS equipment installed in 1989. The life-cycle cost represents the total cost associated with MLSs installed in 1989 and maintained through 2009. The exact relationship between the costs for the first year of ownership and the life-cycle costs is complex and based on the EAM. However, the life-cycle cost is essentially the first-year cost plus the cumulative recurring logistics cost, without inflation.

Table 9-1. COST OF OWNERSHIP FOR COMMERCIAL AVIATION AIRCRAFT

Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition	35,536	35,536
Installation	6,940	11,560
Nonrecurring Logistic	10,032	10,032
Recurring Logistic (First Year)	1,469	1,469
First Year of Ownership	53,977	58,597
Life-Cycle Cost	83,357	87,977

The acquisition costs shown in Table 9-1 are based on manufactured quantities of 500 units per year per manufacturer. The relatively high cost of acquisition is the result of dual MLS avionics being bought and precision DME costs being included with the MLS avionics. Life-cycle cost is, of course, governed by the length of the LCC study period.

9.3.1.2 General Aviation

The data in Tables 9-2 and 9-3 identify the costs of ownership and the anticipated life-cycle costs for general aviation aircraft. Acquisition costs include the distribution costs expected in a competitive market. Nonrecurring logistic support costs (e.g., spare inventory) on a per-aircraft basis are not identified, since they are considered to be inappropriate for the private GA aircraft owner. Recurring logistic support costs for each system are based on the average number of flight hours per month.

High-Performance General Aviation Aircraft

Table 9-2 reflects the anticipated costs of ownership for the high-performance GA aircraft community. The low recurring logistic support costs for each system are based on a limited flight-hours-per-month average of 34.7 hours. For some classes of the high-performance GA community, e.g., corporate or cargo jet aircraft, these costs will increase considerably. However, the typical owner of aircraft equipped with MLS avionics is expected to experience the indicated average maintenance costs.

Table 9-2. COST OF OWNERSHIP FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT

Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition	15,220	15,220
Installation	5,860	9,770
Recurring Logistic (First Year)	135	135
First Year of Ownership	21,215	25,125
Life-Cycle Cost	23,915	27,825

Low-Performance General Aviation Aircraft

Table 9-3 reflects the anticipated costs of ownership for the majority of the GA community -- i.e., owners of low-performance GA aircraft. The maintenance (recurring logistic) per aircraft is low but reasonable because of the average flight time of 15.8 hours per month. The acquisition costs are different from those in Table 7-14, because the LCC allows for normal distributor discounts when the distributor installs the avionics.

Table 9-3. COST OF OWNERSHIP FOR LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT		
Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition*	2,075	2,075
Installation	195	325
Recurring Logistic (First Year)	10	10
First Year of Ownership	2,280	2,410
Life-Cycle Cost	2,460	2,590

*Cost is discounted to allow for distributor installation.

9.3.2 Fleet Life-Cycle Costs

The per-aircraft costs identified in the preceding section are important to GA aircraft owners and small-fleet commercial air carriers. However, the commercial air carriers support large fleets of aircraft and are more concerned with the cumulative costs of system implementation than they are with the proportional costs per aircraft. The cumulative costs include the total costs of acquisition, installation, and recurring and nonrecurring logistics. Cumulative costs also offer better insight into the impact that total cost has on the user community.

The cost-model outputs based on the data developed are shown in Table 9-4 in constant 1980 dollars. Constant dollars (zero inflation rate) permit comparison of costs with any other life-cycle study of comparable length, regardless of the start of implementation, providing that the base costs are presented in 1980 dollars.

Table 9-4 shows that the community incurring the highest life-cycle costs is the high-performance GA aircraft community. This is simply because of the high number of installations (32,925) over the life cycle compared with the number of commercial air carrier installations (5,215), and the cost per system for acquisition ($15,220) compared with that for the low-performance GA aircraft community ($2,075).

Table 9-5 presents the life-cycle costs for the total community in discounted 1980 dollars.

Table 9-4. CUMULATIVE LIFE-CYCLE COSTS FOR MLS IN MILLIONS OF CONSTANT 1980 DOLLARS

Cost Category	Cost by Aircraft Avionics Category			Total
	Low-Performance General Aviation*	High-Performance General Aviation**	Commercial Aviation†	
Acquisition	266.476	501.132	185.320	952.928
Installation	26.405	233.996	49.128	309.529
Nonrecurring Logistic	9.384	27.980	42.254	79.618
Recurring Logistic	12.371	45.905	119.388	177.664
Total	314.636	809.013	396.090	1,519.739

*117,900 new installations; 10,500 retrofit installations.
**22,425 new installations; 10,500 retrofit installations.
†2,415 new installations; 2,800 retrofit installations.

Table 9-5. CUMULATIVE LIFE-CYCLE COSTS FOR MLS IN MILLIONS OF DISCOUNTED 1980 DOLLARS

Cost Category	Cost by Aircraft Avionics Category			Total
	Low-Performance General Aviation	High-Performance General Aviation	Commercial Aviation	
Acquisition	44.354	86.775	51.023	182.152
Installation	4.430	41.297	15.186	60.913
Nonrecurring Logistic	1.701	4.916	12.680	19.297
Recurring Logistic	1.521	5.774	19.408	26.703
Total	52.006	138.762	98.297	289.065

9.3.2.1 Commercial Aviation Aircraft

Figure 9-1 represents the expenditures per year required to implement MLS avionics in the air carrier community. The rapid rise in costs from 1989 through 1992 reflects the costs associated with retrofitting the entire commercial fleet. The logistic support cost reflects the continual increase in support required with an increasing number of systems and is indicative of the high use of commercial aircraft per year.

9.3.2.2 High-Performance General Aviation Aircraft

Figure 9-2 illustrates the cumulative life-cycle costs incurred by the high-performance GA aircraft community. The primary costs associated with MLS implementation are for acquisition, followed by installation. The logistic support costs are relatively low because of the GA maintenance philosophy discussed in Chapter Eight and the relatively low use of high-performance GA aircraft per year.

9.3.2.3 Low-Performance General Aviation Aircraft

Figure 9-3 illustrates the cumulative life-cycle costs for low-performance GA aircraft. Acquisition costs are the major cost driver for this category of aircraft.

9.3.2.4 Total Aviation Community

Figure 9-4 presents the cumulative life-cycle costs for MLS avionics implementation in the entire aviation community for the 21-year life cycle. The data presented in the figure are the result of the implementation scenario chosen.

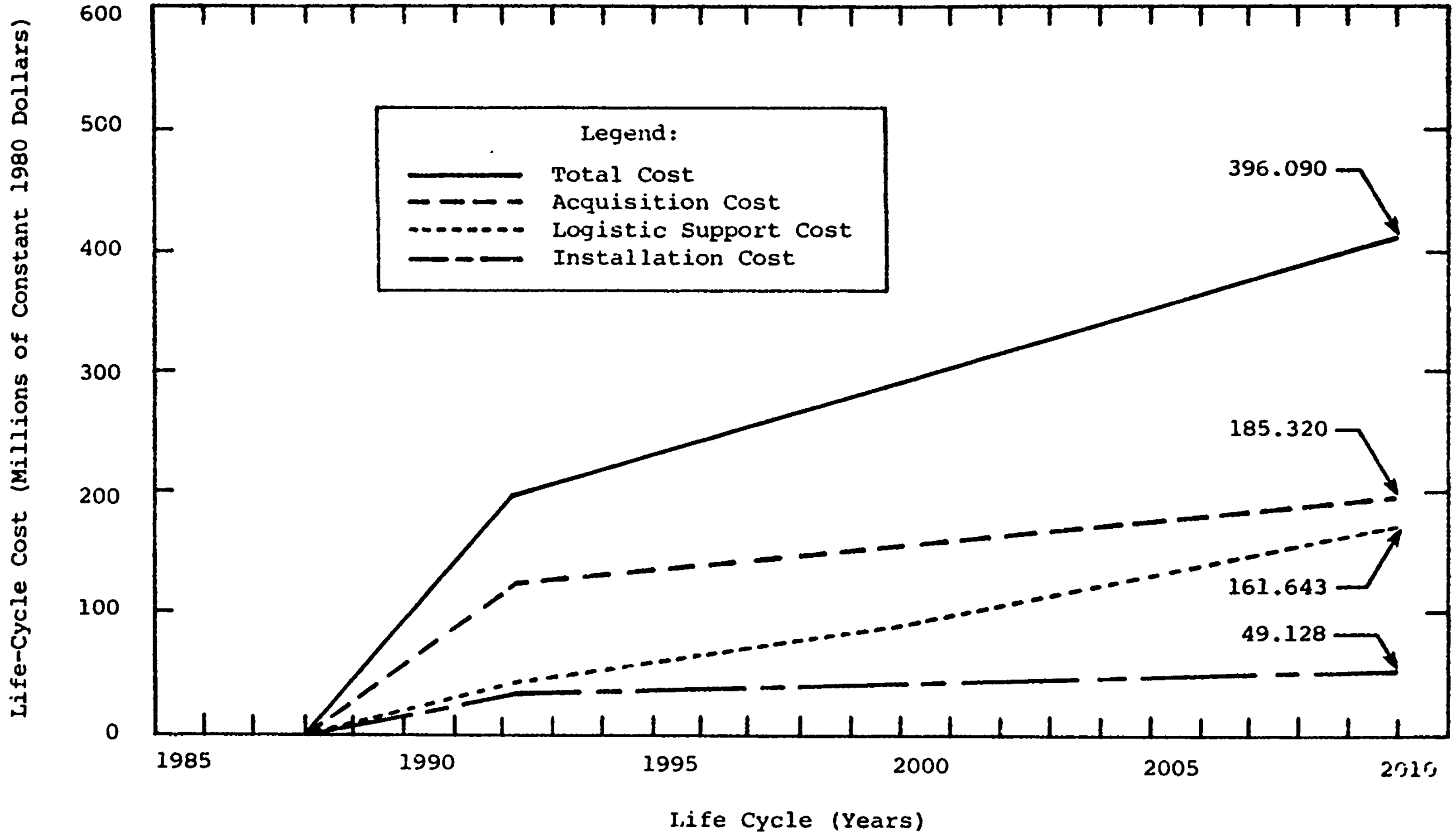

Figure 9-1. CUMULATIVE LIFE-CYCLE COST FOR MLS AIRBORNE SYSTEMS, COMMERCIAL AVIATION AIRCRAFT

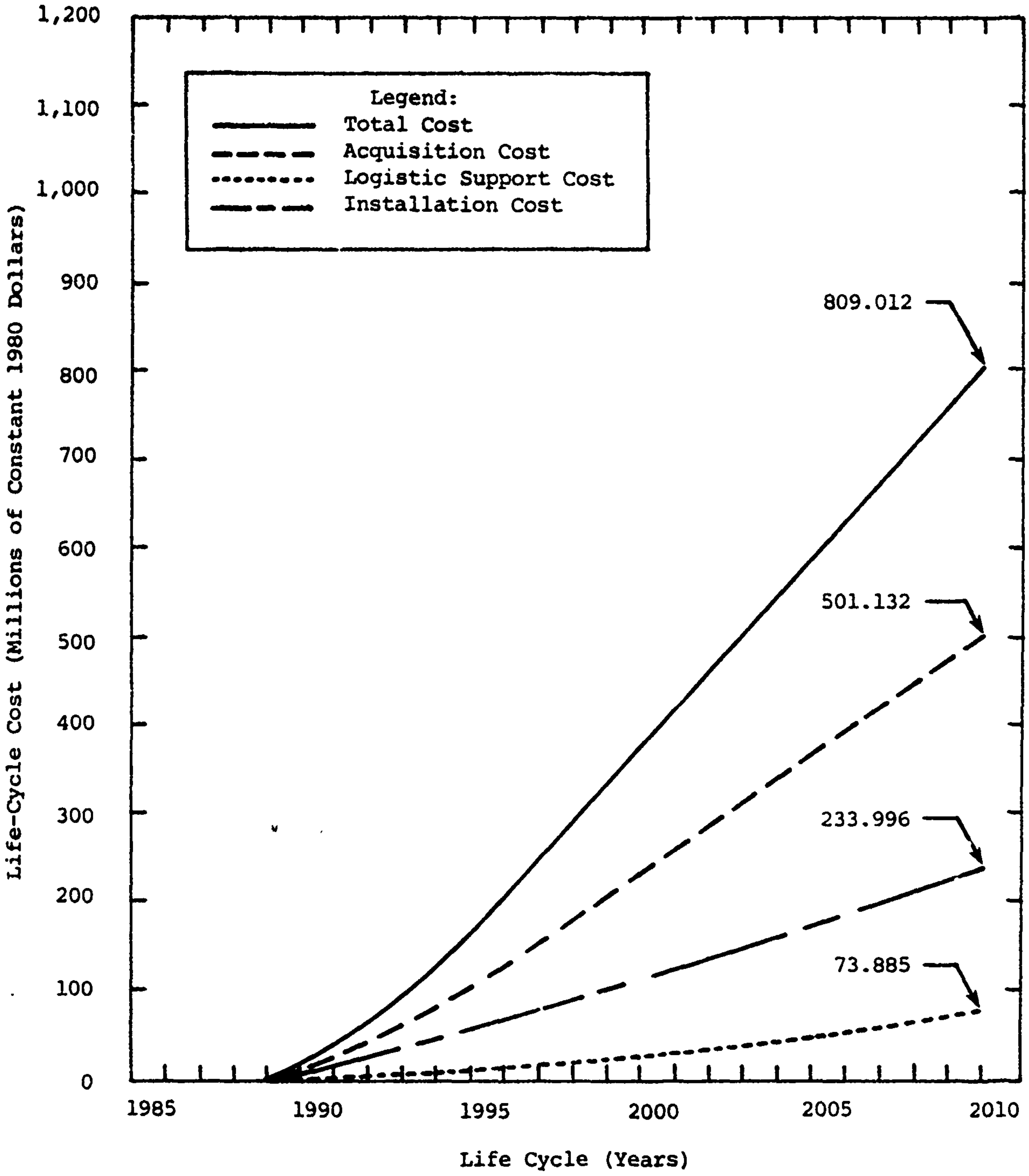

Figure 9-2. CUMULATIVE LIFE-CYCLE COST FOR MLS AIRBORNE SYSTEMS, HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT

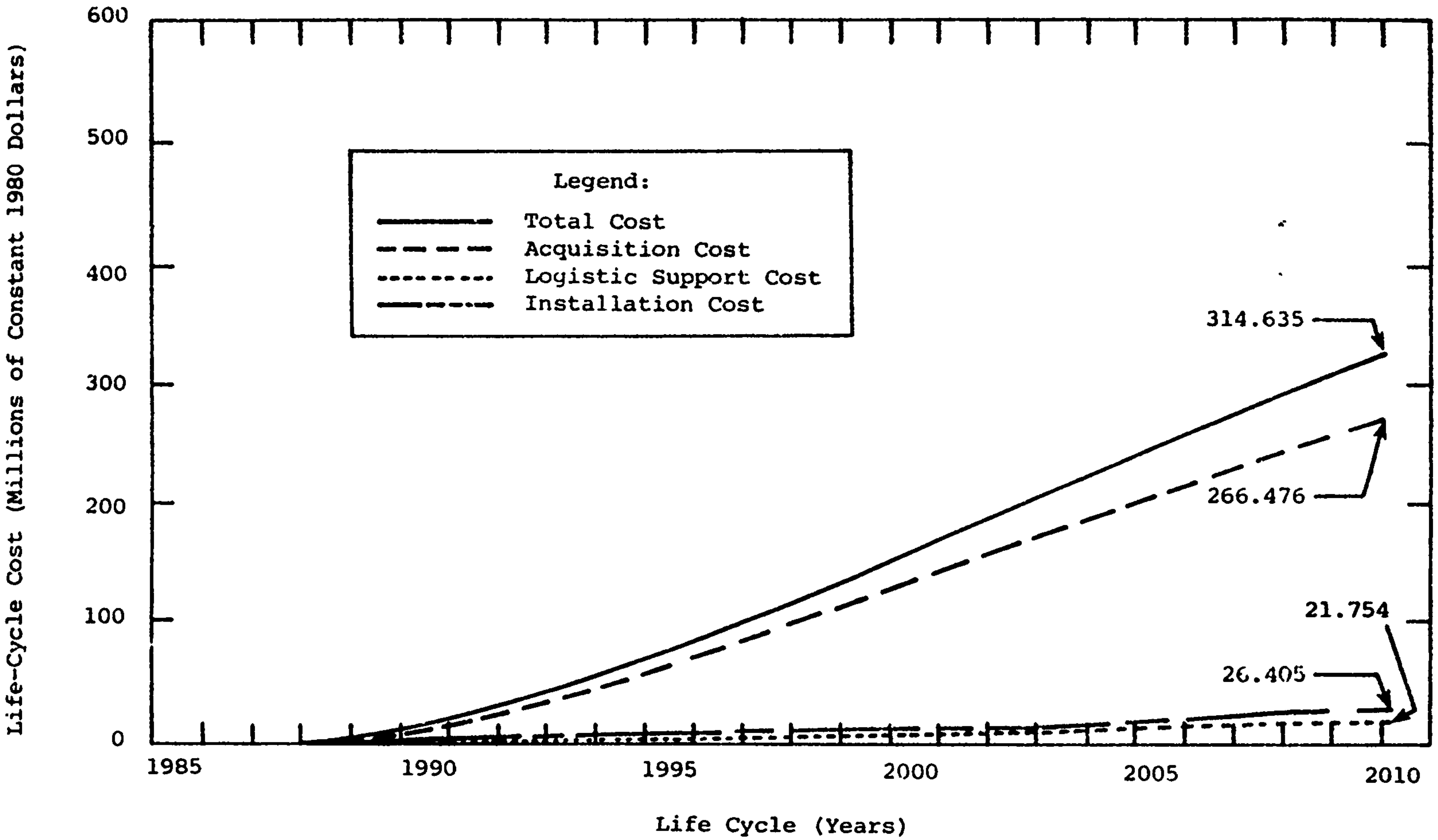

Figure 9-3. CUMULATIVE LIFE-CYCLE COST FOR MLS AIRBORNE SYSTEMS, LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT

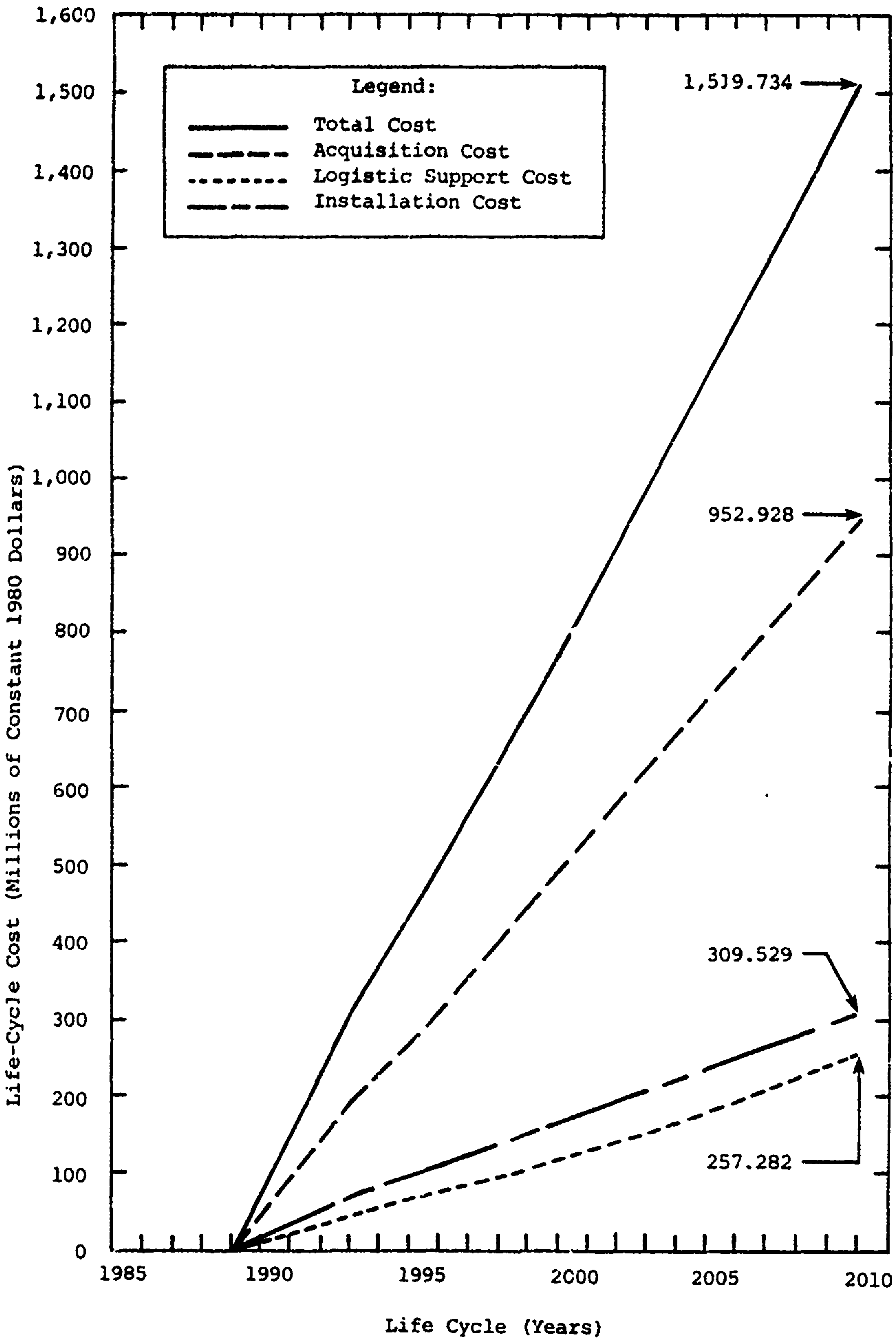

Figure 9-4. CUMULATIVE LIFE-CYCLE COST FOR MLS AIRBORNE SYSTEMS

CHAPTER TEN

RESULTS OF EVALUATION

For this study, ARINC Research developed acquisition, installation, and total life-cycle costs for ground and airborne MLS configurations. Acquisition costs and equipment MTBFs were developed through the application of ARINC Research-formulated inputs to a commercially available parametric pricing model. The baseline equipment designs used for this study were the existing prototype MLS ground and airborne equipments. Total system life-cycle costs were evaluated with ARINC Research-developed ground and airborne economic analysis models. This chapter summarizes the results of the cost analyses.

10.1 COST DATA FOR MLS GROUND CONFIGURATIONS

Acquisition costs were developed for four MLS ground configurations. These configurations and their characteristics are shown in Table 10-1. All four configurations used linear phased-array antennas. The Basic azimuth antennas used conventional phased arrays in which each radiating element is equipped with a phase shifter. The Basic elevation antennas used the thinned-array concept, where four radiating elements are driven by a common phase shifter. The thinned-array concept was also assumed for the SCMLS azimuth and elevation subsystems.

The total development and production costs associated with different production quantities for the SCMLS configuration acquisition are shown in Table 10-2. Similar costs for the Basic configurations are shown in Table 10-3. All costs are presented in constant 1980 dollars.

A direct comparison between the SCMLS and Basic production quantities is not possible, because the Basic production quantities would provide components for the three Basic configurations -- Basic I, Basic II, and Expanded. Both the Basic II and Expanded configurations were assumed to use redundant electronics, so a 75-system production quantity would have to provide 95 sets of electronics. A system-by-system comparison is also not possible, because the costs of the electronics in a Basic I system would be based on the total electronics manufactured for all three Basic configurations.

Table 10-4 presents the unit cost for each configuration, along with the number of system types produced for the production runs.

Table 10-1. EQUIPMENT CONFIGURATIONS CONSIDERED DURING STUDY

Considerations	Configurations by Reliability and Integrity Categories			
	I		II	III
	SCMLS	Basic I	Basic II	Expanded
Equipment Costs To Be Determined	Azimuth electronics Azimuth antenna Elevation electronics Elevation antenna controls Remote maintenance monitor (RMM)	Azimuth electronics Azimuth antenna Elevation electronics Elevation antenna controls Remote maintenance monitor	Dual azimuth electronics Dual elevation electronics Dual controls	1° azimuth antenna
Costs To Be Assumed or Taken From FAA Data	Commercial distance-measuring equipment (DME) Back azimuth same as front azimuth (installed at 10 percent of installations)	Precision DME Back azimuth same as front azimuth (installed at 20 percent of installations)	Azimuth and elevation antennas same as Basic I RMM same as Basic I Dual DME from FAA	All other equipment same as Basic II
System Characteristics	Azimuth beamwidth - 3° Elevation beamwidth - 2° Proportional azimuth - ±10° Sector azimuth - 40° Proportional elevation - 1° to 15° Range - 20 nmi	Azimuth beamwidth - 2° Elevation beamwidth - 1° Proportional azimuth - ±40° Proportional elevation - 1° to 15° Range - 20 nmi	Same as Basic I	Same as Basic II, except azimuth beamwidth - 1° Proportional azimuth - ±60°
Packaging	Weatherproof enclosure	Shelters	Shelters	Shelters

Table 10-2. SCMLS DEVELOPMENT AND MANUFACTURING COSTS FOR THREE-YEAR PRODUCTION RUN					
Subsystem	**Development Cost**	**Quantity Manufacturing Costs (Millions of Constant 1980 Dollars)**			
		75 Systems	110 Systems	145 Systems	180 Systems
Elevation Antenna	0.378	1.691	2.422	3.024	3.655
Azimuth Antenna	0.384	2.440	3.478	4.643	5.223
Electronics	0.441	5.914	8.602	11.239	13.841
Field Monitors	0.046	0.390	0.602	0.765	0.925
Remote Maintenance Monitors	0.003	0.377	0.560	0.741	0.923
Remote Control and Status Panels	0.133	0.356	0.494	0.628	0.759
Integration and Test	0.159	0.344	0.470	0.560	0.660
Total	1.544	11.512	16.628	21.600	25.986
Total Angle Equipment Production Cost (Development plus Manufacturing)		13.056	18.172	23.144	27.530
Distance-Measuring Equipment Cost		3.315	4.862	6.409	7.956
Total System Cost		16.371	23.034	29.553	35.486

Table 10-3. BASIC DEVELOPMENT AND MANUFACTURING COSTS FOR THREE-YEAR PRODUCTION RUN					
Subsystem	Development Cost	Quantity Manufacturing Costs (Millions of Constant 1980 Dollars)			
		75 Systems	110 Systems	145 Systems	180 Systems
Elevation Antenna	0.916	4.501	6.210	7.893	9.114
Azimuth Antenna	0.924	5.346	7.446	9.369	10.875
Azimuth Expanded Antenna	0.416	0.232	0.306	0.402	0.471
Electronics	1.250	14.630	20.080	28.390	36.150
Shelters	0.102	3.212	4.684	6.120	7.516
Field Monitors	0.046	0.438	0.612	0.781	0.978
Remote Maintenance Monitors	0.003	0.387	0.571	0.752	0.936
Remote Control and Status Panels	0.133	0.356	0.494	0.628	0.759
Integration and Test	0.262	0.826	1.116	1.384	1.571
Total	4.052	29.928	41.519	55.719	68.370
Total Angle Equipment Production Cost (Development plus Manufacturing)		33.980	45.571	59.771	72.422
Distance-Measuring Equipment Cost		3.594	5.268	6.952	8.626
Total System Cost		37.574	0.839	66.723	81.048

Table 10-4. MLS UNIT COSTS WITH PRODUCTION RATE VARIABILITY OVER A THREE-YEAR PRODUCTION RUN (MILLIONS OF CONSTANT 1980 DOLLARS)

System Type	Production Quantities and Costs							
	75 Systems		110 Systems		145 Systems		180 Systems	
	Systems Produced	Unit Cost	Systems Produced	Unit Cost	Systems Produced	Unit Cost	Systems Produced	Unit Cost
SCMLS	75	203,300	110	194,400	145	188,800	180	184,900
Basic I	55	410,400	81	384,800	106	372,100	132	361,800
Basic II	13	602,900	19	568,400	25	550,300	31	535,800
Expanded	7	700,000	10	648,200	14	616,400	17	593,700

The costs presented in Tables 10-2 through 10-4 include many parts that were priced as purchased items, including transmitters and DMEs. No cost reductions were assumed for purchased parts for larger MLS production quantities, because we had already assumed large quantity discounts for purchased parts in the initial 75-system production run.

Even with the purchased parts, unit costs for the SCMLS are reduced by approximately 9.1 percent when the production quantity is raised from 75 to 180 systems. The Basic I costs are reduced by 11.8 percent, the Basic II costs by 11.1 percent, and the Expanded costs by 15.2 percent as the Basic production quantity is increased from 75 to 180 systems. The larger reduction in the Expanded system costs is because of the larger quantity of systems for amortization of the development costs for the 1° azimuth antenna.

10.2 LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENT

The 25-year life-cycle costs for each MLS ground configuration are summarized in Table 10-5 in constant 1980 dollars and in Table 10-6 in discounted 1980 dollars. The LCC study used system acquisition costs based on a 120-system production run. The implementation scenario used for the LCC analysis was taken from the draft MLS transition plan; acquiring and deploying 1,177 MLS systems over 22 years. We included a back azimuth system at 20 percent of the Basic I installations and at 10 percent of the SCMLS installations. We ran the LCC study over a 25-year period to examine the recurring logistic support costs without the effects of acquisition and nonrecurring costs.

10.3 DISCUSSION OF SENSITIVITY ANALYSIS

A sensitivity analysis was performed for the following areas:

- Sensitivity of life-cycle costs to variations in system MTBFs
- Shelters versus weatherproof enclosures for Basic I MLS sites

Table 10-5. LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS OR 180 BASIC SYSTEMS (MILLIONS OF CONSTANT 1980 DOLLARS)

Cost Category	Cost by System Type						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	88.149	3.229	172.930	14.379	103.754	37.911	420.352
Installation	89.498	0.635	120.826	2.309	48.956	20.311	282.535
Nonrecurring Logistics	24.704	2.386	22.977	2.850	20.908	18.726	92.551
Recurring Logistics	84.020	5.191	148.263	15.845	75.336	43.720	372.375
Total	286.371	11.441	464.996	35.383	248.954	120.668	1,167.813

Table 10-6. LIFE-CYCLE COSTS FOR MLS GROUND EQUIPMENTS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS OR 180 BASIC SYSTEMS (MILLIONS OF DOLLARS, USING A DISCOUNT RATE OF 10 PERCENT)

Cost Category	Cost by System Type						Total
	SCMLS (463 Systems)	SCMLS Back Azimuth (46 Systems)	Basic I (464 Systems)	Basic I Back Azimuth (92 Systems)	Basic II (188 Systems)	Expanded (62 Systems)	
Acquisition	28.809	1.085	52.684	4.308	22.653	10.201	119.740
Installation	24.173	0.176	30.422	0.572	8.834	4.517	68.694
Nonrecurring Logistics	11.501	1.163	8.732	1.243	8.057	8.223	38.919
Recurring Logistics	14.282	1.018	23.353	2.767	11.087	7.672	60.179
Total	78.765	3.442	115.191	8.890	50.631	30.613	287.532

- Use of an azimuth beamwidth of 2° in lieu of 3° for the SCMLS
- Coverage of 40° for the SCMLS
- Implementation strategies
- Production schedules for MLS equipments

Major variations in data for reliability of the total system were considered to determine if there were any conditions that would significantly change the maintenance costs of the various systems. The configurations were normalized to allow comparisons among systems. It was found that the LCC was relatively insensitive to changes in MTBF. This was not unexpected, because under the centralized maintenance scenario, maintenance costs would not be a dominating cost driver of the LCC.

A limited evaluation was performed to determine the cost impact of eliminating shelters at Basic I MLS sites. It was determined that acquisition costs could be reduced by approximately 10 percent and installation costs by 13 percent. The major cost benefit for logistic support costs was the reduction in the costs of recurring spares as a result of the elimination of the shelters. The assumed MTBF for the shelters was 15 years. The total life-cycle cost for a weatherproof-enclosed Basic I configuration was approximately 11 percent, or $51 million, less than that for a shelterized Basic I configuration for the given implementation strategy.

Table 10-7 illustrates the variation in costs between different SCMLS azimuth beamwidth and coverage configurations. A narrower beamwidth for the system evaluated results in an increase in life-cycle costs of approximately 3 percent, while wider coverage incurs a 9.5 percent increase in cost. A narrower beamwidth combined with wider coverage results in an increase in life-cycle cost of approximately 15 percent.

Table 10-7. LIFE-CYCLE COSTS FOR DIFFERENT SCMLS AZIMUTH CONFIGURATIONS, BASED ON THREE-YEAR PRODUCTION RUN, 180 SCMLS

Cost Category	Cost by SCMLS Configuration (Millions of Constant 1980 Dollars)			
	3° Azimuth ±10° Coverage	2° Azimuth ±10° Coverage	3° Azimuth ±40° Coverage	2° Azimuth ±40° Coverage
Acquisition	88.149	91.184	96.873	102.045
Installation	89.498	89.498	89.498	89.498
Nonrecurring Logistics	24.704	25.006	25.879	26.447
Recurring Logistics	84.020	89.651	101.324	112.020
Total	286.371	295.339	313.574	330.010

MLS implementation strategies directly affected the study costs. We investigated a number of different strategies derived from our basic study strategy. The total acquisition, installation, and nonrecurring logistic support costs were not affected by implementation strategy as long as an equal number of systems were acquired for any given strategy. This was expected as long as constant dollars were used. The recurring costs are time-dependent, however, even in constant dollars, because spares and maintenance actions and costs are dependent on system MTBF. A faster implementation rate would increase the recurring logistic support costs.

We evaluated the single-system implementation strategy of buying only Basic I configurations and compared the results to the mixed-system implementation strategy. The LCC results showed that acquisition and installation costs were higher for a single system. This was expected because of the elimination of the lower cost SCMLS configuration. For the same implementation period and an equal number of systems purchased, there was a 53 percent reduction in nonrecurring logistic support costs and a slight reduction in recurring logistic support costs. In addition, an all-Basic I implementation required more system maintenance hours on an annual basis -- 575,900 hours versus 551,700 hours -- but at an increase in cost of only $0.35 million.

We also evaluated a new transition plan strategy to acquire 1,250 systems over a 15-year period. The costs associated with this implementation plan were presented for information purposes only.

The production schedules for MLS equipments were evaluated with respect to both cost reduction through quantity production and the effect of two manufacturers for a single configuration compared with a single manufacturer. The cost reduction with varied production rates is shown in Table 10-4. A comparison of data for dual manufacturers producing 75 SCMLS each and a single manufacturer producing 145 SCMLS showed all costs to be higher for the dual-manufacturer strategy -- approximately 8 percent higher for acquisition, 100 percent higher for nonrecurring logistics, 54 percent higher for recurring logistics, and 27 percent higher for the total life-cycle cost.

10.4 COST DATA FOR MLS AIRBORNE CONFIGURATIONS

In addition to developing acquisition costs for ground equipment, this study also developed acquisition costs for the three MLS airborne configurations -- air carrier aircraft avionics, high-performance general aviation aircraft avionics, and low-performance general aviation aircraft avionics.

The total avionics acquisition costs associated with the MLS airborne configurations are shown in Tables 10-8, 10-9, and 10-10. The values indicate the probable selling price of the avionics to the respective users. Appropriate markups for distribution are included on the basis of known or expected practices of the avionics manufacturers. All costs are based on 1980 dollars without inflation. Costs may vary as a function of the production volume dictated by user demand.

Table 10-8. AIR CARRIER AVIONICS COST PER MLS INSTALLATION, BASED ON 500 UNITS PER YEAR (1980 DOLLARS)

Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	2	8,880	17,760
MLS Control Panel	2	1,026	2,052
MLS Auxiliary Data Display	1	2,539	2,539
C-Band Antenna	2	150	300
Precision DME	1	11,385	11,385
Computer Interface	1	1,500	1,500
Total			35,536

Table 10-9. HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT AVIONICS COST PER MLS INSTALLATION, BASED ON 1,000 UNITS PER YEAR (1980 DOLLARS)

Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	1	7,219	7,219
MLS Control Panel	1	923	923
C-Band Antenna	1	195	195
L-Band Antenna	1	117	117
Conventional DME	1	5,850	5,850
CDI Display	1	916	916
Total			15,220

Table 10-10. LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT AVIONICS COST PER MLS INSTALLATION, BASED ON 1,000 UNITS PER YEAR (1980 DOLLARS)			
Equipment	Quantity	Cost per Unit	Total System Cost
MLS Receiver-Processor	1	1,648	1,648
C-Band Antenna	1	346	346
CDI Display	1	600	600
Total			2,594

The costs developed in this study were based on existing prototype equipments. Actual costs were derived only for equipment that needed to be developed for MLS installations.

10.5 LIFE-CYCLE COSTS FOR MLS AIRBORNE EQUIPMENT

The life-cycle costs for the MLS avionics used in each aviation community are presented in Tables 10-11, 10-12, and 10-13 for both new and retrofit installations. The unit acquisition cost for low-performance GA aircraft in Table 10-13 is different from the acquisition cost illustrated in Table 10-10, because the LCC allows for the normal distributor discount if the distributor installs the avionics in the aircraft.

Table 10-11. COST OF OWNERSHIP FOR COMMERCIAL AVIATION AIRCRAFT		
Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition	35,536	35,536
Installation	6,940	11,560
Nonrecurring Logistic	10,032	10,032
Recurring Logistic (First Year)	1,469	1,469
First Year of Ownership	53,977	58,597
Life-Cycle Cost	83,357	87,977

Table 10-12. COST OF OWNERSHIP FOR HIGH-PERFORMANCE GENERAL AVIATION AIRCRAFT		
Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition	15,220	15,220
Installation	5,860	9,770
Recurring Logistic (First Year)	135	135
First Year of Ownership	21,215	25,125
Life-Cycle Cost	23,915	27,825

Table 10-13. COST OF OWNERSHIP FOR LOW-PERFORMANCE GENERAL AVIATION AIRCRAFT		
Cost Category	Costs (Constant 1980 Dollars)	
	New Installation	Retrofit Installation
Acquisition*	2,075	2,075
Installation	195	325
Recurring Logistic (First Year)	10	10
First Year of Ownership	2,280	2,410
Life-Cycle Cost	2,460	2,590

*Cost is discounted to allow for distributor installation.

Table 10-14 presents the cumulative life-cycle costs for the entire aviation community in constant 1980 dollars; Table 10-15 presents these costs in discounted 1980 dollars. The individual aircraft owner costs are likely to be of the most interest to the general aviation community, while the air carrier community will probably be more concerned with the cumulative costs of system implementation. No sensitivity analysis was conducted for the MLS avionics.

Table 10-14. CUMULATIVE LIFE-CYCLE COSTS FOR MLS IN MILLIONS OF CONSTANT 1980 DOLLARS				
Cost Category	Cost by Aircraft Avionics Category			Total
	Low-Performance General Aviation*	High-Performance General Aviation**	Commercial Aviation†	
Acquisition	266.476	501.132	185.320	952.928
Installation	26.405	233.996	49.128	309.529
Nonrecurring Logistic	9.384	27.980	42.254	79.618
Recurring Logistic	12.371	45.905	119.388	177.664
Total	314.636	809.013	396.090	1,519.739

*117,900 new installations; 10,500 retrofit installations.
**22,425 new installations; 10,500 retrofit installations.
†2,415 new installations; 2,800 retrofit installations.

Table 10-15. CUMULATIVE LIFE-CYCLE COSTS FOR MLS IN MILLIONS OF DISCOUNTED 1980 DOLLARS				
Cost Category	Cost by Aircraft Avionic Category			Total
	Low-Performance General Aviation	High-Performance General Aviation	Commercial Aviation	
Acquisition	44.354	86.775	51.023	182.152
Installation	4.430	41.297	15.186	60.913
Nonrecurring Logistic	1.701	4.916	12.680	19.297
Recurring Logistic	1.521	5.774	19.408	26.703
Total	52.006	138.762	98.297	289.065

10.6 RELATION OF THE MLS COST ANALYSIS TO IMPLEMENTATION OF A NATIONAL MICROWAVE LANDING SYSTEM

The purpose of this study was to evaluate the costs of the ground and airborne equipments of the MLS concept; it was not intended to address other key issues that will most likely affect the implementation of a National Microwave Landing System (NMLS). Among these issues are such questions as what is the best implementation strategy, how many systems of what type should be deployed and where, and is there an optimum beam-width/coverage system with respect to dollars spent.

The installation costs in this study may be considered to be those for a worst-case scenario, because we did not consider any cost benefits that may accrue during installation because of existing trenches, cables, pads, and roadways. In addition, the analyses and results reported herein have been based on assumptions of deployment and maintenance scenarios as well as production quantities of equipment. Any changes to those assumptions will change the LCC results. The sensitivity analysis offers some insight into how the LCC results would change with different implementation strategies, equipment deployment strategies, and manufacturer-producibility strategies.

APPENDIX A

MLS GROUND CONFIGURATIONS DETAILED COSTS

This appendix presents a typical RCA PRICE input worksheet and output data sheet. It also presents system parts lists and costs for Basic I and SCMLS configurations. The parts lists denote manufactured and purchased parts.

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PRICE Input Data Worksheet

Basic Modes

File name:
Sheet 11 of 18

**PRICE 84 (This must be used only as the first line of the file.)

Title: AZWEC COURSE PHASE PC BOARD

Date:

General A

Production Quantity QTY	Prototypes PROTOS	Weight (lbs) WT	Volume (ft^3) VOL	MODE
110	1	0.45	0.016	1

1 E/M ITEM
2 MECHANICAL ITEM
6 MODIFIED ITEM
7 ECIRP
10 DESIGN TO COST

General B

Quantity/Next Higher Assembly QTYNHA	NHA Integration Factors Electronic INTEGE	NHA Integration Factors Structural INTEGS	Specification Level PLTFM	Year of Economics YRECON	Year of Technology YRTECH
1	0.3	0.3	1.3	1980	1980

Mechanical/Structural

Structure Weight WS	Manufacturing Complexity MCPLXS	New Structure NEWST	Design Repeat DESRPS	Equipment Classification MECID	Mechanical Reliability MREL
0	-	-		-	

Electronics

Electronics Weight/ft^3 WECF	Manufacturing Complexity MCPLXE	New Electronics NEWEL	Design Repeat DESRPE	Equipment Classification CMPID	Electronic Reliability EREL
28.1	6.90	1.0	0.0	-	-

Development

Development Start DSTART	1st Prototype Complete DFPRO	Development Complete DLPRO	Engineering Complexity ECMPLX	Tooling & Test Equip. DTLGTS	Prototype Activity PROSUP
180	C	581	1.0	0.3	-

Production

Production Start PSTART	First Article Delivery PFAD	Production Complete PEND	Cost-Process Factor CPF	Tooling & Test Equip. PTLGTS	Rate/Month Tooling RATOOL
681	582	584	0.90	0.3	0.0

Actual Cost Data (Mode 7 only)

Average Unit AUCOST	Production Total PTCOST	Prototypes PRCOST	Development Total DTCOST

Additional Data (Mode 10 only)

Electronic Volume Fraction USEVOL	Structural Weight/ft^3 WSCF	Target Cost TARCST

Notes:

DWG #4046810
#4046528

GC 1813 6/80 Note: Inputs in shaded area are optional.

RCA

Figure A-1. TYPICAL PRICE DATA INPUT SHEET

- - - PRICE 84 - - -
ALL ELECTRONIC ITEM

DATE 20-APR-81 TIME 10:03 (281058) FILENAME: AZBW3.DAT

AZWEC COURSE PHASE PC BOARD

PRODUCTION QUANTITY	110	UNIT WEIGHT	0.45	MODE	1
PROTOTYPE QUANTITY	1.0	UNIT VOLUME	0.02	QUANTITY/NHA	1

UNIT PROD COST 388.62 COST PROCESS FACTOR 0 MONTHLY PROD RATE 4.54

PROGRAM COST($ 1)	DEVELOPMENT	PRODUCTION	TOTAL COST
ENGINEERING			
DRAFTING	10856.	1525.	12381.
DESIGN	35370.	4279.	39649.
SYSTEMS	1596.	-	1596.
PROJECT MGMT	2230.	2633.	4863.
DATA	762.	767.	1529.
SUBTOTAL(ENG)	50814.	9203.	60017.
MANUFACTURING			
PRODUCTION	-	42748.	42748.
PROTOTYPE	1096.	-	1096.
TOOL-TEST EQ	102.	217.	319.
SUBTOTAL(MFG)	1199.	42965.	44164.
TOTAL COST	52012.	52168.	104180.

DESIGN FACTORS	ELECTRONIC	PRODUCT DESCRIPTORS	
WEIGHT	0.450*	ENGINEERING COMPLEXITY	1.00*
DENSITY	28.125*	PROTOTYPE SUPPORT	1.0
MFG. COMPLEXITY	6.900	PROTO SCHEDULE FACTOR	.200
NEW DESIGN	1.000	ELECT VOL FRACTION	1.000*
DESIGN REPEAT	0.000	PLATFORM	1.3
EQUIPMENT CLASS	*****	YEAR OF TECHNOLOGY	1980
ENGINEERING CHANGES	.100*	RELIABILITY FACTOR	1.0*
INTEGRATION LEVEL	0.3	MTBF(FIELD)	32987*

SCHEDULE	START		FIRST ITEM		FINISH	
DEVELOPMENT	JAN 80	(11)	NOV 80*	(6)	MAY 81	(17)
PRODUCTION	MAY 81	(13)	MAY 82	(24)	MAY 84	(37)

SUPPLEMENTAL INFORMATION		TOOLING & PROCESS FACTORS	
YEAR OF ECONOMICS	1980	DEVELOPMENT TOOLING	.300
ESCALATION	0.00	PRODUCTION TOOLING	.300
T-1 COST	628.22*	RATE TOOLING	0
AMORTIZED UNIT COST	474.25*	PRICE IMPROVEMENT FACTOR	.900
DEV COST MULTIPLIER	1.38	UNIT LEARNING CURVE	.913*
PROD COST MULTIPLIER	1.38		

COST RANGES	DEVELOPMENT	PRODUCTION	TOTAL COST
FROM	46716.	46642.	93357.
CENTER	52012.	52168.	104180.
TO	60074.	59984.	120058.

Figure A-2. TYPICAL PRICE DATA OUTPUT SHEET

Table A-1. BASIC I AZIMUTH ANTENNA PARTS LIST AND COSTS

Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Chassis	M	59401	1	651	6552	7203	7203
Ground Plane	M	88225	1	233	1777	2010	2010
Radome	M	50858	1	832	5011	5843	5843
Undercarriage	M	248365	1	229	1899	2128	2128
Waveguide Element	M	175286	54	1	103	104	5616
Waveguide Plate	M	486587	10	1	16	17	170
Waveguide Clamp	M	1526463	6	1	1	2	12
Air Duct	M	163715	2	3	295	298	596
PCB 1	M	30107	1	237	492	729	729
PCB 2	M	30685	1	233	484	717	717
PCB 3	M	32987	1	208	406	614	614
PCB 4	M	27398	1	244	469	713	713
PCB 5	M	35446	1	195	374	569	569
PCB 6	M	37815	2	74	243	317	634
PCB 7	M	43245	1	150	256	406	406
BSU Panel	M	35283	1	126	152	278	278
Card Rack	M	173032	1	5	323	328	328
Environmental Control Box	P	109019	1	1	217	218	218
Safety Switches	P	391741	1	1	31	32	32
Power Supply	P	40000	4	3	520	523	2092
Phase Shifter	M	196422	50	3	251	254	12700
Power Divider	M	154452	1	131	381	512	512
Video Amplifier	P	17735	1	5	902	907	907
Detector	P	660766	1	11	2029	2040	2040
Coupler	P	154568	1	2	315	317	317
Fire Extinguisher	P	204304	1	1	69	70	70
Air Conditioner	P	85949	2	3	583	586	1172
Integral Monitor	M	87114	1	219	943	1162	1162
Junction Box	P	-	1	10	1771	1781	1781
Obstruction Light	P	-	1	2	362	364	364
Junction Box	P	-	4	1	44	45	180
EMI Filter	P	-	1	2	322	324	324
Fan	P	-	4	1	72	73	292
Integration & Test	M	-	1	246	1406	1652	1652

* M = Manufactured
P = Purchased

Table A-2. BASIC I ELEVATION ANTENNA PARTS LIST AND COSTS

Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Chassis	M	115022	1	1214	12849	14063	14063
Radome	M	67870	1	407	2211	2618	2618
Air Duct	M	122195	2	37	663	700	1400
OCI/Antenna Assembly	M	56176	1	695	4251	4946	4946
Phase Shifter	M	196462	24	3	251	254	6096
Antenna Element	M	93478	1	204	1034	1238	1238
PC Board	M	117314	1	110	400	510	510
Monitor Waveguide	M	134819	2	42	365	407	814
OCI Radome	M	167443	1	58	200	258	258
Status Panel	M	35283	1	217	161	378	378
PCB 1	M	17700	1	267	1126	1393	1393
PCB 2	M	21444	1	192	638	830	830
PCB 3	M	18309	1	252	1018	1270	1270
PCB 4	M	18058	1	258	1062	1320	1320
Electronic Rack	M	173032	1	5	323	328	328
4-Way Power Divider	P	58656	1	2	354	356	356
6-Way Power Divider	P	27304	4	1	418	419	1676
Power Supply	P	40000	5	2	644	646	3230
Air Conditioner	P	85949	1	3	583	586	586
Blink Lights	P	-	1	2	362	364	364
EMI Filter	P	-	1	2	322	324	324
Lightning Board	M	20936	2	1	370	371	742
Vent Fan	P	-	2	1	72	73	146
Environmental Control	P	2187887	6	1	15	16	96
Bus Bar	P	-	14	1	3	4	56
Power Box	P	32588	3	1	96	97	291
Relay	P	17049	1	1	51	52	52
Integration & Test	M	-	1	249	883	1132	1132

* M = Manufactured
P = Purchased

Table A-1. BASIC I AZIMUTH ELECTRONICS PARTS LIST AND COSTS							
Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Azimuth Maintenance Monitor							
PCB 1	M	32718	3	12	221	233	699
PCB 2	M	43189	1	36	191	227	227
PCB 3	M	35252	1	39	191	230	230
PCB 4	M	33468	1	31	219	250	250
PCB 5	M	32835	1	22	208	230	230
PCB 6	M	32527	1	63	256	319	319
PCB 7	M	39542	1	31	138	169	169
PCB 8	M	30976	2	31	256	287	574
PCB 9	M	33437	1	121	254	375	375
PCB 10	M	31510	2	18	241	259	518
PCB 11	M	33112	1	32	228	260	260
PCB 12	M	32635	1	94	226	320	320
PCB 13	M	36131	1	80	180	260	260
PCB 14	M	36753	1	26	170	196	196
PCB 15	M	35706	1	19	161	180	180
PCB 16	M	33157	1	62	294	356	356
PCB 17	M	36700	1	26	171	197	197
PCB 18	M	33468	2	29	205	234	468
PCB 19	M	33157	3	7	217	224	672
PCB 20	M	32565	1	48	266	314	314
PCB 21	M	30301	1	25	290	315	315
Front Panel PCB	M	19829	1	35	284	319	319
Front Panel	M	162673	1	1[illegible]	277	289	289
Chassis	M	133780	1	10	534	544	544
Integration & Test	M	-	1	83	328	411	411
Transmitter	P	30000	1	212	48,300	48,512	48,512

* M = Manufactured
P = Purchased

(continued)

Table A-1. (continued)

Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Azimuth Local Control Status							
PCB 1	M	31994	1	9	271	280	280
PCB 2	M	30022	1	24	283	307	307
PCB 3	M	34770	1	80	226	306	306
PCB 4	M	34127	2	41	201	242	484
PCB 5	M	39542	1	63	157	220	220
PCB 6	M	35093	1	79	221	300	300
PCB 7	M	36753	1	16	170	186	186
PCB 8	M	35730	1	26	162	188	188
PCB 9	M	32638	1	69	303	372	372
PCB 10	M	32278	1	84	460	544	544
Oscillator	P	107029	1	1	136	137	137
Front Panel PCB	M	21075	1	33	270	303	303
Front Panel	M	162673	1	12	277	289	289
Chassis	M	123984	1	12	651	663	663
Integration & Test	M	-	1	61	201	262	262
Electronics Power Supplies							
Power Supplies	P	40000	4	3	644	647	2588
Front Panel	M	194135	1	1	207	208	208
Chassis	M	137606	1	3	496	499	499
Integration & Test	M	-	1	48	92	140	140
Maintenance Monitor Power Supplies							
Power Supplies	P	40000	3	3	643	646	1938
Front Panel	M	194135	1	1	205	206	206
Chassis	M	137606	1	3	502	505	505
Integration & Test	M	-	1	57	91	148	148

* M = Manufactured
P = Purchased

Table A-4 BASIC I ELEVATION ELECTRONICS PARTS LIST AND COSTS

Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Elevation Maintenance Monitor							
PCB 1	M	32718	3	12	221	233	699
PCB 2	M	43189	1	36	191	227	227
PCB 3	M	35252	1	39	191	230	230
PCB 4	M	33468	1	31	219	250	250
PCB 5	M	32835	1	22	208	230	230
PCB 6	M	39542	1	31	138	169	169
PCB 7	M	30967	3	31	256	287	861
PCB 8	M	41589	1	166	453	619	619
PCB 9	M	31510	2	18	241	259	518
PCB 10	M	33112	1	31	229	260	260
PCB 11	M	32835	1	94	226	320	320
PCB 12	M	36131	1	81	179	260	260
PCB 13	M	35706	1	19	161	180	180
PCB 14	M	38957	1	176	479	655	655
PCB 15	M	41368	1	133	270	403	403
PCB 16	M	36700	1	26	171	197	197
PCB 17	M	33468	1	29	205	234	234
PCB 18	M	36284	1	163	367	530	530
PCB 19	M	33157	3	7	217	224	672
PCB 20	M	32565	1	48	266	314	314
PCB 21	M	30301	1	25	290	315	315
Front Panel PCB	M	19829	1	35	284	319	319
Front Panel	M	162673	1	12	277	289	289
Chassis	M	133780	1	10	534	544	544
Integration & Test	M	—	1	83	328	411	411
Transmitter	P	30000	1	212	48,300	48,512	48,512

* M = Manufactured
P = Purchased

(continued)

Table A-4. (continued)

Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Elevation Local Control/Status							
PCB 1	M	31994	1	8	272	280	280
PCB 2	M	30022	1	25	293	318	318
PCB 3	M	38665	1	188	331	519	519
PCB 4	M	34127	2	41	209	250	500
PCB 5	M	35730	1	26	168	194	194
PCB 6	M	37216	1	162	499	661	661
PCB 7	M	37216	1	162	499	661	661
Oscillator	P	107029	1	1	136	137	137
Front Panel PCB	M	21075	1	36	245	281	281
Front Panel	M	162673	1	12	281	293	293
Chassis	M	123[illegible]4	1	11	660	671	671
Integration & Test	M	-	1	46	147	193	193
Electronics Power Supplies							
Power Supplies	P	40000	4	3	644	647	2588
Front Panel	M	194135	1	1	207	208	208
Chassis	M	137606	1	3	496	499	499
Integration & Test	M	-	1	48	92	140	140
Maintenance Monitor Power Supplies							
Power Supplies	P	40000	3	3	642	646	1938
Front Panel	M	194135	1	1	205	206	206
Chassis	M	137606	1	3	502	505	505
Integration & Test	M	-	1	57	91	148	148

* M = Manufactured
  P = Purchased

Table A-5. BASIC I PERIPHERAL EQUIPMENT PARTS LIST AND COSTS							
Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Azimuth and Elevation Cabinet							
Cabinet	P	66359	2	1	332	333	666
Grill	P	229440	2	1	33	34	68
Blower	P	89279	2	1	211	212	424
Amplifiers	P	17735	8	1	502	503	4024
RF Detector	P	41443	6	3	475	478	[illegible]
Directional Coupler	P	154365	2	1	316	317	634
Integration & Test	P	-	2	221	270	491	982
Azimuth and Elevation Shelter							
Shelter	P	* *	2	31	11270	11301	22602
AC Power Distribution Box	P	* *	2	1	282	283	566
Air Conditioner	P	85949	2	1	500	501	1002
Telephone	P	* *	2	1	44	45	90
Work Bench	P	* *	2	1	136	137	274
Work Cabinet	P	* *	2	1	327	328	656
Exhaust Fan	P	* *	2	1	164	165	330
Fire Extinguisher	P	* *	2	1	68	69	138
Nitrogen Supply Bottle	P	* *	2	1	403	404	808
Air Exhaust Duct	M	* *	2	13	312	325	650
Lights	P	* *	2	1	362	363	726
Air Intake	M	* *	2	29	801	830	1660
OCI Antenna Bracket	M	* *	2	31	403	434	868
ID Antenna Bracket	M	* *	2	16	379	395	790
Waveguide Assembly	M	175286	4	1	104	105	420
Radome	M	104591	4	43	594	637	2548
Signal Distribution Box	P	* *	2	8	2897	2905	5810
Integration & Test	M	-	2	117	355	472	944
INTEGRATION AND TEST							
Azimuth Subsystem	M	-	1	825	2635	3460	3460
Elevation Subsystem	M	-	1	747	2106	2853	2853
Basic I System	M	-	1	807	2422	3229	3229

* * - All items included in 15-year MTBF of shelter.

* M = Manufactured
P = Purchased

Table A-6. SCMLS AZIMUTH SYSTEM PARTS LIST AND COSTS							
Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
PCB 1	M	20978	1	104	337	441	441
PCB 2	M	20130	1	130	532	662	662
PCB 3	M	16852	1	166	759	925	925
PCB 4	M	21156	1	193	559	752	752
PCB 5	M	16852	1	166	759	925	925
PCB 6	M	17502	1	157	693	850	850
PC Chassis	M	184493	1	7	242	249	249
Antenna Chassis	M	41330	1	487	2251	2738	2738
Undercarriage	M	-	1	229	1872	2101	2101
Radome	M	66452	1	428	2377	2805	2805
Antenna Element	M	193720	52	1	79	80	4160
Antenna PC Board	M	393727	1	34	207	241	241
Column Radiator	M	144408	1	84	242	326	326
Phase Shifter	M	196462	10	11	287	298	2980
Phase Shifter Driver	M	112454	10	4	76	80	800
Connectors	P	248590	67	1	25	26	1742
Timer	P	8450	1	1	46	47	47
Voltmeter	P	-	1	1	31	32	32
Volt & Timer Chassis	M	242921	1	20	124	144	144
Power Supply	P	40000	3	4	644	648	1944
Status Panel	M	35283	1	82	135	217	217
Blink Lights	P	249062	1	2	362	364	364
Circuit Breaker	P	311442	1	1	104	105	105
Transmitter	P	30000	1	168	32200	32368	32368
Battery Pack	P	26304	1	4	781	785	785
Telephone	P	-	1	1	44	45	45
Air Conditioner	P	69398	1	3	583	586	586
Integral Monitor	M	31143	1	191	290	481	481
Field Monitor	M	31143	1	191	290	481	481
Modem	P	14904	1	3	483	486	486
6-Way Power Divider	P	27304	3	1	419	420	1260
2-Way Power Divider	P	82431	2	1	201	202	404
Voltage Regulator	P	-	1	2	322	324	324
Lightning Boards	M	50000	2	1	402	403	806
Maintenance Shelter	M	581659	1	1	242	243	243
Integration & Test	M	-	1	319	1183	1502	1502
System Integration & Test	M	-	1	225	1209	1434	1434

* M = Manufactured
P = Purchased

Table A-7. SCMLS ELEVATION SYSTEM PARTS LIST AND COSTS							
Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
PCB 1	M	20978	1	104	337	441	441
PCB 2	M	20130	1	130	532	662	662
PCB 3	M	16852	1	166	759	925	925
PCB 4	M	21156	1	193	559	752	752
PCB 5	M	16852	1	166	759	925	925
PCB 6	M	17502	1	157	693	850	850
PC Chassis	M	184493	1	7	242	249	249
Antenna Chassis	M	33670	1	506	3084	3590	3590
Undercarriage	M	-	1	229	1872	2101	2101
Radome	M	93040	1	192	960	1152	1152
Antenna Element	M	90325	1	167	864	1031	1031
Antenna PC Board	M	367910	1	32	249	281	281
Column Radiator	M	-	-	-	-	-	-
Phase Shifter	M	196462	10	11	287	298	2980
Phase Shifter Driver	M	112454	10	4	76	80	800
Connectors	M	248590	20	1	25	26	520
Timer	P	8450	1	1	46	47	47
Voltmeter	P	-	1	1	31	32	32
Vol[illegible]mer Chassis	M	242921	1	20	124	144	144
Powe[illegible]y	P	40000	3	4	644	648	1944
Status Panel	M	35283	1	82	135	217	217
Blink Lights	P	249062	1	2	362	364	364
Circuit Breaker	P	311442	1	1	104	105	105
Transmitter	P	30000	1	168	32200	32368	32368
Battery Pack	P	26304	1	4	781	785	785
Telephone	P	-	1	1	44	45	45
Air Conditioner	P	69398	1	3	583	586	586
Integral Monitor	P	31143	1	191	290	481	481
Field Monitor	P	31143	1	191	290	481	481
Modem	P	14904	1	3	483	486	486
6-Way Power Divider	P	27304	3	1	419	420	1260
2-Way Power Divider	P	82431	2	1	201	202	404
Voltage Regulator	P	-	1	2	322	324	324
Lightning Boards	M	50000	2	1	402	403	806
Maintenance Shelter	P	581659	1	1	242	243	243
Integration & Test	M	-	1	332	1147	1479	1479

* M = Manufacturer
P = Purchase

Table A-8. MLS MONITORS AND OTHER EQUIPMENT

Item	Source*	MTBF	System Quantity	Cost			
				Development ($/Unit)	Production ($/Unit)	Unit (Dollars)	System (Dollars)
Azimuth Field Monitor							
Base Plate	M	299016	1	7	229	236	236
Lower Mast	M	223129	1	14	459	473	473
Edge Slot Element	M	175450	1	2	102	104	104
Power Box	P	221629	2	1	129	130	260
Detector	P	41443	1	1	475	476	476
Amplifier	P	17735	1	1	502	503	503
Integration & Test	M	-	1	8	27	35	35
Elevation Field Monitor							
Base Plate	M	282262	1	7	263	270	270
Monitor Pole	M	207410	1	27	245	272	272
Lower Mast	M	223129	1	16	459	475	475
Element Extension	M	210337	1	26	236	262	262
Nesting Channel	M	279709	1	17	114	131	131
Mast Section	M	216182	1	25	220	245	245
AC Power Box	P	221629	2	1	129	130	260
Lights	P	249062	1	2	365	367	367
Detector	P		1	1	475	476	476
Amplifier	P		1	1	502	503	503
Integration & Test	M	-	1	14	53	67	67
Tower Remote Panel							
PCB 1	M	35871	1	209	505	714	714
PCB 2	M	34308	1	195	408	603	603
Front Panel PCB	M	21412	1	96	339	435	435
Front Panel	M	162673	1	83	340	423	423
Remote Chassis	M	133991	1	28	645	673	673
Power Supply	P	40000	2	3	644	647	1294
Integration & Test	M	-	1	67	108	175	175
Other Items							
Antenna Switch **	P	50000	1	2	644	646	646
Uninterruptable ** Power Supply	P	50000	1	4	1612	1616	1616
Remote Maintenance Monitor Terminal	P	50000	1	5	1934	1939	1939
Remote Status Panel	M	50000	1	2	285	287	287

* M = Manufactured
P = Purchased

** Basic I System

APPENDIX B

INSTALLATION COSTS

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1. INTRODUCTION

Ground equipment installation costs were determined on the basis of probable personnel, equipment, material, trenching, and flight inspection costs. These cost categories take into consideration the total installation rather than just the component parts such as site preparation, site construction, and actual equipment installation.

It was assumed that the MLS azimuth site would be located on an extended runway centerline 1,000 feet beyond the stop end of the runway and that the monitor site would be 200 feet in front of the azimuth site for the Basic configuration and 100 feet for the SCMLS configuration. A shelter, if used, would be 200 feet to the side of the azimuth antenna. The elevation site would be located 1,000 feet from the runway threshold, and the monitor site would be similar to the azimuth site. A shelter, if used, would be within 20 feet of the elevation antenna. We assumed that the SCMLS would be installed on a 6,900-foot runway, the Basic MLS on a 9,600-foot runway, and the Expanded MLS on a 15,900-foot runway. These are approximate average distances from the Systems Research and Development Service (SRDS) MLS Technical Data Package submitted to Airways Facilities.

2. PERSONNEL COSTS

Personnel costs are illustrated in Table B-1 under three categories -- FAA personnel, MLS contractor personnel, and subcontractor personnel. FAA personnel are those required by various FAA orders to plan and oversee landing aids installations. MLS contractor personnel are technical people who will plan the installation and provide on-site supervision and assistance to subcontractor personnel during site preparation, construction, equipment installation, and equipment tune-up and checkout. In addition, MLS contractor personnel may assist in the site-certification process. Subcontractor personnel are those who will actually prepare and construct the MLS site. Electricians listed under subcontractor personnel will be responsible for all electrical work other than cable installation in trenches. Electricians involved in trenching work are included in trenching costs.

The man-months listed in Table B-1 are based on the assumption that FAA and MLS contractor personnel will be experienced in installing landing aids. Subcontractor personnel manning levels are based on the expected productivity for a particular job. The total man-months are based on past estimates for installing MLS equipment and on the conclusions reached in NASA Technical Memorandum 78588 of August 1979, *Site Preparation and Installation of the Prototype Texas Instruments Basic Narrow Configuration Microwave Landing System*. A man-month was assumed to consist of 21 working days.

Costs for FAA personnel are taken from Office of Personnel Management Services civilian pay rates for economic analyses and program evaluations under OMB Circular A-94. These costs include employee benefits, training, and some TDY. MLS contractor personnel costs are based on 1980 industry averages. Subcontractor personnel costs are taken from editions of Means

Table B-1. PERSONNEL COSTS ASSOCIATED WITH MLS INSTALLATION								
Location	Personnel	Cost per Year	Expected Costs* and Time per Installation					
			SCMLS		Basic		Expanded	
			Man-Months	Cost	Man-Months	Cost	Man-Months	Cost
FAA Personnel								
Region	Project Engineer	42,907	0.8	2,900	1.0	3,600	1.2	4,300
	Electronic Engineer	36,234	0.8	2,400	1.0	3,000	1.2	3,600
	Draftsman	17,016	0.5	700	0.5	700	0.7	1,000
On Site	Resident Engineer	36,234	1.0	3,000	2.0	6,000	3.0	9,000
	Field Technician	30,329	1.0	2,500	1.5	3,800	2.0	5,100
	Per diem at $50 a day	N/A	2.0	2,100	3.5	3,700	5.0	5,300
	Subtotal	--	--	13,600	--	20,800	--	28,300
MLS Contractor Personnel								
In Plant	Engineering	83,300	0.4	2,800	0.5	3,500	0.6	4,200
	Drafting	58,000	0.6	2,900	0.8	3,300	1.0	4,800
On Site	Field Engineering	54,700	2.0	9,100	3.0	13,700	4.0	18,200
	Per diem at $50 a day	N/A	2.0	2,100	3.0	3,200	4.0	4,200
	Subtotal	--	--	16,900	—	24,300	--	31,400
Subcontractor Personnel								
On Site	Electrician	47,100	0.4	1,600	0.7	2,700	1.0	3,900
	Truck Driver	33,200	0.4	1,100	0.4	1,100	0.4	2,600
	Loader Operator	43,500	0.5	1,800	0.6	2,200	0.6	2,200
	Compactor Operator	43,500	0.5	1,800	0.6	2,200	0.6	2,200
	Concrete Foreman	48,900	0.9	3,700	1.0	4,100	1.0	4,100
	Carpenter	41,300	0.9	3,100	1.0	3,400	1.0	3,400
	Concrete Finisher	39,700	0.2	700	0.2	700	0.2	700
	Laborer	33,052	0.7	1,900	[illegible]	2,200	0.9	2,500
	Surveyor	42,500	0.4	1,400	0.5	1,800	0.6	2,100
	Crane Operator	44,800	0.1	400	0.1	400	0.1	400
	Subtotal	--	--	17,500	--	20,800	--	24,300
	Total Cost	--	--	48,000	--	65,900	--	84,000

*Constant 1980 dollars.

Building Construction Cost Data for 1979, 1980, and 1981. All costs are calculated in 1980 dollars.

3. EQUIPMENT COSTS

Equipment costs were developed by analyzing the types of equipment required for site construction, such as backhoes, trucks, compactors, and cranes. Daily or monthly rental costs from Means Cost Data were used where appropriate. The equipment costs do not include excavating equipment used for trenching. It was assumed that the Basic and Expanded MLS sites would have the same equipment costs because, except for trenching costs, the sites are essentially similar. We also included $1,800 in equipment costs for preflight inspection flights by contractor-provided aircraft.

4. MATERIAL COSTS

Material costs were developed on the basis of the materials expected to be used in the construction of the site. It was assumed that a SCMLS would use approximately 17 cubic yards of concrete, based on Hazeltine drawings. A Basic or Expanded site would use approximately 25 cubic yards of concrete, based on Bendix drawings of the Basic wide installation at NASA Wallops Island, Virginia. We used an approximate figure of $295 per cubic yard of concrete from Means Cost Data for 3,000 psi concrete. This cost includes forms and reinforcing rods. Other costs include gravel fill, counterpoise wire, anchor bolts, and so forth. An additional $3,000 was added to Basic and Expanded sites to account for use of the pressurized waveguide. The nominal price for the pressurized waveguide accessory kit is $1,500 per azimuth or elevation site.

5. TRENCHING COSTS

Trenching costs were developed by analyzing the general trenching requirements for Bendix, Hazeltine, and Texas Instruments MLSs. We decided on a standardized general trench four feet deep and eighteen inches wide. Approximately five inches of sand fill would be on the bottom, and the signal cable would then be laid. Additional fill material and power cables would be installed if required, with approximately 12 inches of separation between the signal cables and power cables. After another 12 inches of backfill, three protective ground wires of bare copper would be installed.

Trenching installation costs include excavation, backfill, material and equipment costs for backfill, and labor costs for installing required cables. Table B-2 details the typical trenching installation costs and cable costs that go into each trench. Cable costs were determined by analyzing the cable types required for the Basic wide MLS installation at NASA Wallops Island. The variance in cable costs is the result of different types and numbers of cables being installed in a particular trench. It was assumed that all MLS synchronization cables and site to remote control/status indications would be six-twisted-pair cable protected by three bare ground

Table B-2. TYPICAL TRENCHING COSTS BY MLS TYPE IN 1980 DOLLARS

Cable Runs	Typical Trenching Costs (Dollars per Foot)			Trenching Distance and Cost by System Type					
				SCMLS		Basic		Expanded	
	Installation	Cable	Total	Distance (Feet)	Cost (Dollars)	Distance (Feet)	Cost (Dollars)	Distance (Feet)	Cost (Dollars)
Azimuth Electronics to Elevation Electronics	4.40	0.90	5.30	6,900	36,570	9,800	51,940	15,900	84,270
Azimuth Electronics to Azimuth Antenna	11.55	15.60	27.15	N/A	N/A	250	6,788	250	6,788
Azimuth Electronics to Azimuth Monitor	6.05	1.30	7.35	100	735	350	2,573	350	2,573
Power to Azimuth Electronics	4.00	4.65	8.65	15	130	15	130	15	130
Power to Elevation Electronics	4.00	2.75	6.75	15	130	15	130	15	130
Elevation Electronics to Elevation Antenna	9.15	5.95	15.10	0	0	50	755	50	755
Elevation Electronics to Elevation Monitor	6.05	1.30	7.35	100	735	350	2,573	350	2,573
Total Intersite Trenching Costs	--	--	--	--	38,300	--	64,889	--	97,219
Site to Remote Control/Status	4.40	0.90	5.30	5,000	26,500	5,000	26,500	5,000	26,500
Total (Rounded to Nearest Hundred Dollars)	--	--	--	--	64,800	--	91,400	--	123,700

wires. Because the SCMLS is a nonshelter MLS, there are no trenching costs for system electronics to system antenna connections.

The trenching costs by system type in Table B-2 are based on the total installation and cable costs, which are national averages taken from Means Construction Cost Data. A standard trench and fill were developed for this analysis, because trenching costs are known to vary widely throughout the United States.

6. ROADWAYS AND POWER

Roadway costs were developed by assuming that approximately 1,500 feet of gravel road would be built to the site. We used the factor $6.65 per foot for the cost of a gravel road, taken from Defense Communicati Agency Circular 600-60-1.

We assumed that the cost of providing power to the MLS site would be an average of $14,000 per site, on the basis of data in NASA TM 78588.

7. FLIGHT INSPECTION

Table B-3 illustrates flight inspection time and costs. The costs are based on the use of FAA aircraft and flight crews for flight inspection. Costs are for on-site flight hours only and do not include the cost of flying from a base airport to the MLS site to be certified. These transient costs would depend on whether or not the inspection aircraft is making a trip for the MLS checkout only and where the base is in relation to the MLS site.

The flight hours of Table B-3 have been updated from NASA TM 78588 and ICAO AWOP presentations through conversations with SRDS personnel. The base cost per flight hour used in the table is from the Airways Facilities flight inspection program study and is the projected 1980 composite flight inspection rate.

Table B-3. FLIGHT INSPECTION TIME AND COSTS (1980 DOLLARS)

Cost Category	Base Cost	Expected Time and Cost by Installation					
		SCMLS		Basic		Expanded	
		Time	Cost	Time	Cost	Time	Cost
Flight Hours	$ 2,158 per hour	10 hours	21,580	15 hours	32,370	20 hours	43,160
Flight Crew	$42,907 per year	0.8 man-months	2,900	1.0 man-months	3,600	1.2 man-months	4,300
Per Diem	$50 per day	0.8 man-months	840	1.0 man-months	1,[illegible]	1.2 man-months	1,260
	Total*	--	25,320	--	37,020	--	48,720

*Rounded to nearest $100.

APPENDIX C

LIFE-CYCLE-COST MODEL OUTPUTS FOR
GROUND EQUIPMENT

CONTENTS

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SYSTEM TYPE: SCHLS (180)

ANNUAL MAINTENANCE HOURS AND LABOR COSTS

1985

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1986

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1987

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	18884.	77.82	275357.
PREVENTIVE MAINT	1594.	6.58	31910.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	20481.	84.40	307267.
BASE LEVEL REPAIR	2403.	1.36	41868.
DEPOT LEVEL REPAIR	126.	0.07	2409.
TOTAL SYSTEM MAINT	23011.		351745.

1988

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	21880.	90.16	319033.
PREVENTIVE MAINT	1853.	7.64	35656.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	23733.	97.80	354689.
BASE LEVEL REPAIR	2790.	1.58	48605.
DEPOT LEVEL REPAIR	147.	0.08	3029.
TOTAL SYSTEM MAINT	26670.		406324.

1989

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	24872.	102.50	362669.
PREVENTIVE MAINT	2110.	8.70	39402.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	26983.	111.19	402071.
BASE LEVEL REPAIR	3177.	1.80	55343.
DEPOT LEVEL REPAIR	167.	0.09	3449.
TOTAL SYSTEM MAINT	30327.		460863.

1990

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	27863.	114.82	406272.
PREVENTIVE MAINT	2367.	9.75	43148.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	30230.	124.57	449420.
BASE LEVEL REPAIR	3564.	2.02	62080.
DEPOT LEVEL REPAIR	188.	0.11	3869.
TOTAL SYSTEM MAINT	33981.		515369.

1991

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	30851.	127.13	449848.
PREVENTIVE MAINT	2624.	10.81	46894.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	33475.	137.95	496742.
BASE LEVEL REPAIR	3950.	2.23	68818.
DEPOT LEVEL REPAIR	208.	0.12	4289.
TOTAL SYSTEM MAINT	37634.		569849.

1992

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	34051.	140.32	496511.
PREVENTIVE MAINT	2899.	11.95	50907.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	36951.	152.27	547418.
BASE LEVEL REPAIR	4365.	2.47	76036.
DEPOT LEVEL REPAIR	230.	0.13	4739.
TOTAL SYSTEM MAINT	41545.		628193.

1993

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	39168.	161.41	571124.
PREVENTIVE MAINT	3340.	13.76	57329.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	42508.	175.17	628453.
BASE LEVEL REPAIR	5028.	2.84	87586.
DEPOT LEVEL REPAIR	265.	0.15	5459.
TOTAL SYSTEM MAINT	47801.		721498.

1994

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	44495.	183.36	648795.
PREVENTIVE MAINT	3798.	15.65	64018.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	48294.	199.01	712813.
BASE LEVEL REPAIR	5718.	3.23	99617.
DEPOT LEVEL REPAIR	301.	0.17	6209.
TOTAL SYSTEM MAINT	54313.		818639.

1995

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	49606.	204.42	723319.
PREVENTIVE MAINT	4239.	17.47	70440.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	53845.	221.89	793759.
BASE LEVEL REPAIR	6381.	3.6.	111167.
DEPOT LEVEL REPAIR	336.	0.19	6928.
TOTAL SYSTEM MAINT	60562.		911854.

1996

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	55140.	227.23	804016.
PREVENTIVE MAINT	4716.	19.43	77396.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	59856.	246.66	881412.
BASE LEVEL REPAIR	7100.	4.02	123679.
DEPOT LEVEL REPAIR	374.	0.21	7708.
TOTAL SYSTEM MAINT	67330.		1012799.

1997

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	60672.	250.02	884679.
PREVENTIVE MAINT	5193.	21.40	84353.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	65865.	271.42	969032.
BASE LEVEL REPAIR	7818.	4.42	136191.
DEPOT LEVEL REPAIR	411.	0.23	8488.
TOTAL SYSTEM MAINT	74095.		1113711.

1998

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	64714.	266.66	943606.
PREVENTIVE MAINT	5542.	22.84	89437.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	70255.	289.51	1033043.
BASE LEVEL REPAIR	8343.	4.72	145335.
DEPOT LEVEL REPAIR	439.	0.25	9058.
TOTAL SYSTEM MAINT	79037.		1187436.

1999

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	68967.	284.20	1005620.
PREVENTIVE MAINT	5909.	24.35	94788.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	74875.	308.55	1100408.
BASE LEVEL REPAIR	8895.	5.03	154960.
DEPOT LEVEL REPAIR	468.	0.26	9658.
TOTAL SYSTEM MAINT	84239.		1265025.

2000

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	73006.	300.85	1064520.
PREVENTIVE MAINT	6257.	25.79	99872.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	79263.	326.64	1164392.
BASE LEVEL REPAIR	9420.	5.33	164103.
DEPOT LEVEL REPAIR	496.	0.28	10228.
TOTAL SYSTEM MAINT	89180.		1338723.

2001

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	77682.	320.12	1132705.
PREVENTIVE MAINT	6661.	27.45	105758.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	84343.	347.57	1238464.
BASE LEVEL REPAIR	10028.	5.67	174691.
DEPOT LEVEL REPAIR	528.	0.30	10887.
TOTAL SYSTEM MAINT	94899.		1424042.

2002

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	81933.	337.63	1194679.
PREVENTIVE MAINT	7028.	28.96	111110.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	88961.	366.60	1305789.
BASE LEVEL REPAIR	10581.	5.98	184315.
DEPOT LEVEL REPAIR	557.	0.31	11487.
TOTAL SYSTEM MAINT	100098.		1501592.

2003

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	86395.	356.02	1259740.
PREVENTIVE MAINT	7413.	30.55	116729.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	93808.	386.57	1376469.
BASE LEVEL REPAIR	11161.	6.31	194422.
DEPOT LEVEL REPAIR	587.	0.33	12117.
TOTAL SYSTEM MAINT	105556.		1583008.

2004

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	90856.	374.41	1324791.
PREVENTIVE MAINT	7799.	32.14	122348.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	98655.	406.54	1447138.
BASE LEVEL REPAIR	11741.	6.64	204528.
DEPOT LEVEL REPAIR	618.	0.35	12747.
TOTAL SYSTEM MAINT	111013.		1664413.

2005

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	95104.	391.91	1386734.
PREVENTIVE MAINT	8166.	33.65	127699.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	103270.	425.56	1514433.
BASE LEVEL REPAIR	12293.	6.95	214152.
DEPOT LEVEL REPAIR	647.	0.37	13347.
TOTAL SYSTEM MAINT	116210.		1741932.

2006

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	98927.	407.66	1442475.
PREVENTIVE MAINT	8496.	35.01	132515.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	107423.	442.68	1574990.
BASE LEVEL REPAIR	12791.	7.23	222815.
DEPOT LEVEL REPAIR	673.	0.38	13887.
TOTAL SYSTEM MAINT	120887.		1811692.

2007

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	98927.	407.66	1442475.
PREVENTIVE MAINT	8496.	35.01	132515.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	107423.	442.68	1574990.
BASE LEVEL REPAIR	12791.	7.23	222815.
DEPOT LEVEL REPAIR	673.	0.38	13887.
TOTAL SYSTEM MAINT	120887.		1811692.

2008

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	98927.	407.66	1442475.
PREVENTIVE MAINT	8496.	35.01	132515.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	107423.	442.68	1574990.
BASE LEVEL REPAIR	12791.	7.23	222815.
DEPOT LEVEL REPAIR	673.	0.38	13887.
TOTAL SYSTEM MAINT	120887.		1811692.

2009

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	98927.	407.66	1442475.
PREVENTIVE MAINT	8496.	35.01	132515.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	107423.	442.68	1574990.
BASE LEVEL REPAIR	12791.	7.23	222815.
DEPOT LEVEL REPAIR	673.	0.38	13887.
TOTAL SYSTEM MAINT	120887.		1811692.

TOTALS

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1441846.	5941.67	21023914.
PREVENTIVE MAINT	123496.	508.91	1999255.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1565342.	6450.58	23023172.
BASE LEVEL REPAIR	185920.	5.16	3238755.
DEPOT LEVEL REPAIR	9785.	5.53	201854.
TOTAL SYSTEM MAINT	1761046.		26463782.

SYSTEM TYPE: DCMLS (180)

CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS

	1985			1986			1987		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.	0.	0.00	0.	18884.	77.82	275357.
PREVENTIVE MAINT	0.	0.00	0.	0.	0.00	0.	1596.	6.58	31910.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.	0.	0.00	0.	20481.	84.40	307267.
BASE LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	2403.	1.36	41848.
DEPOT LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	126.	0.07	2609.
TOTAL SYSTEM MAINT	0.		0.	0.		0.	23011.		351745.

	1988			1989			1990		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	40764.	167.98	594390.	65636.	270.48	957059.	93499.	385.30	1363331.
PREVENTIVE MAINT	3450.	14.22	67566.	5560.	22.91	106968.	7927.	32.67	150117.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	44214.	182.20	661956.	71196.	293.39	1064027.	101426.	417.96	1513447.
BASE LEVEL REPAIR	5194.	2.94	90473.	8371.	4.73	145816.	11934.	6.75	207896.
DEPOT LEVEL REPAIR	273.	0.15	5639.	441.	0.25	9088.	628.	0.36	12957.
TOTAL SYSTEM MAINT	49681.		758068.	80007.		1218931.	113988.		1734300.

	1991			1992			1993		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	124350.	512.43	1813179.	158401.	652.75	2309689.	197570.	814.16	2880814.
PREVENTIVE MAINT	10551.	43.48	197010.	13451.	55.43	247918.	16790.	69.19	305247.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	134901.	555.91	2010189.	171852.	708.18	2557607.	214360.	883.35	3186061.
BASE LEVEL REPAIR	15885.	8.98	276714.	20249.	11.45	352750.	25277.	14.30	440336.
DEPOT LEVEL REPAIR	836.	0.47	17246.	1066.	0.60	21985.	1330.	0.75	27444.
TOTAL SYSTEM MAINT	151622.		2304149.	193167.		2932342.	240968.		3653840.

	1994			1995			1996		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	242065.	997.52	3529609.	291671.	1201.94	4252928.	346811.	1429.17	5056944.
PREVENTIVE MAINT	20589.	84.84	369265.	24828.	102.31	439705.	29544.	121.75	517101.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	262654.	1082.36	3898874.	316499.	1304.25	4692633.	376355.	1550.91	5574045.
BASE LEVEL REPAIR	30996.	17.53	539953.	37377.	21.14	651120.	44477.	25.16	774799.
DEPOT LEVEL REPAIR	1631.	0.92	33652.	1967.	1.11	40581.	2341.	1.32	48289.
TOTAL SYSTEM MAINT	295281.		4472479.	355843.		5384333.	423173.		6397133.

	1997			1998			1999		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	407484.	1679.19	5941622.	472197.	1945.87	6885228.	541164.	2230.07	7890848.
PREVENTIVE MAINT	34737.	143.15	601454	40278.	165.98	690891.	46187.	190.33	785680.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	442220.	1822.34	6543077.	512476.	2111.85	7576120.	587351.	2420.40	8676528.
BASE LEVEL REPAIR	52295.	29.58	910990.	60638.	34.30	1056325.	69533.	39.33	1211285.
DEPOT LEVEL REPAIR	2752.	1.56	56777.	3191.	1.81	65835.	3660.	2.07	75493.
TOTAL SYSTEM MAINT	497268.		7510844.	576305.		8698279.	660544.		9963304.

	2000			2001			2002		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	614170.	2530.92	8955367.	691852.	2851.04	10088072.	773785.	3188.67	11282751.
PREVENTIVE MAINT	52444.	216.12	885552.	59105.	243.57	991310.	66133.	272.53	1102420.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	666614.	2747.04	9840920.	750958.	3094.61	11079384.	839918.	3461.20	12385173.
BASE LEVEL REPAIR	78954.	44.66	1375388.	88982.	50.33	1550079.	99562.	56.31	1734394.
DEPOT LEVEL REPAIR	4155.	2.35	85720.	4683.	2.65	96608.	5240.	2.96	108095.
TOTAL SYSTEM MAINT	749724.		11302027.	844623.		12726069.	944721.		14227661.

	2003			2004			2005		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	860'80.	3544.70	12542491.	951035.	3919.10	13867282.	1046139.	4311.01	15254016.
PREVENTIVE MAINT	73547.	303.08	1219148.	81346.	335.22	1341496.	89511.	368.87	1469195.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	933726.	3847.77	13761642.	1032381.	4254.32	15208780.	1135651.	4679.88	16723213.
BASE LEVEL REPAIR	110723.	62.63	1928816.	122464.	69.27	2133343.	134757.	76.22	2347496.
DEPOT LEVEL REPAIR	5828.	3.30	120212.	6445.	3.65	132959.	7092.	4.01	146306.
TOTAL SYSTEM MAINT	1050277.		15810669.	1161290.		17475082.	12?7500.		19217014.

	2006			2007			2008		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1145066.	4718.68	16696491.	1243993.	5126.34	18138966.	1342919.	5534.01	19581440.
PREVENTIVE MAINT	98007.	403.88	1601710.	106503.	438.89	1734225.	114999.	473.90	1866740.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	1243073.	5122.55	18298202.	1350496.	5565.23	19873192.	1457919.	6007.91	21448182.
BASE LEVEL REPAIR	147548.	83.45	2570311.	160338.	90.69	2793125.	173129.	97.92	3015940.
DEPOT LEVEL REPAIR	7766.	4.39	160193.	8439.	4.77	174080.	9112.	5.15	187967.
TOTAL SYSTEM MAINT	1398387.		21028706.	1519273.		22840398.	1640160.		24652090.

	2009		
LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1441846.	5941.67	21023914.
PREVENTIVE MAINT	123496.	508.71	1999255.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1565342.	6450.38	23023172.
BASE LEVEL REPAIR	185920.	105.16	3238755.
DEPOT LEVEL REPAIR	9785.	5.53	201854.
TOTAL SYSTEM MAINT	1761046.		26463782.

SYSTEM: SCMLS (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

NONRECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	4776020.	109451.	41396.
SHIPPING	0.	0.	79843.	12803.	12803.
INVENTORY MGT	0.	0.	36000.	0.	0.
SUPPORT EQUIP	0.	0.	190000.	0.	0.
TRAINING	0.	0.	127650.	18850.	20300.
DATA MANAGEMENT	0.	0.	15720000.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	20929234.	141104.	74499.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	111783.	129080.	105782.	144804.	142567.
SHIPPING	12803.	12803.	13718.	21949.	22863.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	21050.	18850.	21750.	33350.	37000.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	145636.	160733.	141250.	200102.	202430.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	139091.	220254.	161629.	134615.	137434.
SHIPPING	21948.	23777.	23777.	17376.	18290.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	31900.	38450.	36250.	26100.	29750.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	192939.	282481.	221656.	178091.	185474.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	142613.	129929.	134637.	189372.	270928.
SHIPPING	17376.	20119.	18290.	19205.	19205.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	26100.	30450.	27550.	31200.	29000.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	186089.	180498.	180477.	239777.	319133.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	186948.	265845.	0.	0.	0.	7674178.
SHIPPING	18290.	16461.	0.	0.	0.	423420.
INVENTORY MGT	0.	0.	0.	0.	0.	36000.
SUPPORT EQUIP	0.	0.	0.	0.	0.	190000.
TRAINING	27550.	26850.	0.	0.	0.	659950.
DATA MANAGEMENT	0.	0.	0.	0.	0.	15720000.
FACILITIES	0.	0.	0.	0.	0.	0.
ANNUAL TOTAL	232788.	309156.	0.	0.	0.	24703562.

SYSTEM: SCMLS (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR10.00

RECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	508589.	521580.	539916.
ON-SITE MAINT	0.	0.	346474.	400205.	453094.
OFF-SITE MAINT	0.	0.	183028.	213409.	242991.
INVENTORY MGT	0.	0.	4500.	4500.	4500.
SUPPORT EQUIP	0.	0.	147.	171.	195.
TRAINING	0.	0.	12765.	14650.	16680.
DATA MANAGEMENT	0.	0.	312000.	312000.	312000.
FACILITIES	0.	0.	78000.	78000.	78000.
SITE OPERATION	0.	0.	53721.	62365.	71010.
ANNUAL TOTAL	0.	0.	1500024.	1606881.	1719187.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	743135.	761007.	780613.	904653.	938310.
ON-SITE MAINT	507554.	561185.	618621.	710472.	806099.
OFF-SITE MAINT	272572.	302153.	333848.	384559.	437303.
INVENTORY MGT	4500.	4500.	4500.	4500.	4500.
SUPPORT EQUIP	219.	242.	268.	308.	351.
TRAINING	18785.	20670.	22845.	26180.	29880.
DATA MANAGEMENT	312000.	312000.	312000.	312000.	312000.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	79653.	88300.	9756[illegible]	112.31.	127818.
ANNUAL TOTAL	2016420.	2128058.	224825.	2533054.	2734349.

COST CATEGORY	1995	19[illegible]	1997	1998	1999
SPARES	966223.	1185192.	1215130.	1334502.	1363683.
ON-SITE MAINT	897860.	997230.	1096566.	1169140.	1245518.
OFF-SITE MAINT	488094.	543031.	597968.	638114.	680374.
INVENTORY MGT	4500.	4500.	4500.	4500.	4500.
SUPPORT EQUIP	391.	433.	479.	512.	546.
TRAINING	33070.	36915.	40540.	43150.	46125.
DATA MANAGEMENT	312000.	312000.	312000.	312000.	312000.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	142638.	158692.	174747.	186479.	198829.
ANNUAL TOTAL	2922776.	3315996.	3519931.	3766397.	3929574.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	1387003.	1597535.	1621603.	1655539.	1826383.
ON-SITE MAINT	1318064.	1402050.	1478389.	1558533.	1638666.
OFF-SITE MAINT	720520.	767005.	809264.	853636.	898009.
INVENTORY MGT	4500.	4500.	4500.	4500.	4500.
SUPPORT EQUIP	578.	615.	649.	685.	720.
TRAINING	48735.	51780.	54535.	57655.	60555.
DATA MANAGEMENT	312000.	312000.	312000.	312000.	312000.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	210541.	224145.	236495.	249462.	262429.
ANNUAL TOTAL	4079961.	4437631.	4595435.	4770010.	5081261.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	1849629.	1959976.	1959976.	1959976.	1959976.	29540140.
ON-SITE MAINT	1714973.	1783642.	1783642.	1783642.	1783642.	24056062.
OFF-SITE MAINT	940268.	978301.	978301.	978301.	978301.	14220230.
INVENTORY MGT	4500.	4500.	4500.	4500.	4500.	103500.
SUPPORT EQUIP	754.	784.	784.	784.	784.	11403.
TRAINING	63310.	65995.	65995.	65995.	65995.	962805.
DATA MANAGEMENT	312000.	312000.	312000.	312000.	312000.	7176000.
FACILITIES	78000.	78000.	78000.	78000.	78000.	1794000.
SITE OPERATION	274779.	285893.	285893.	285893.	285893.	4155641.
ANNUAL TOTAL	5238212.	5469092.	5469092.	5469092.	5469092.	84019800.

SYSTEM: SCMLS (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00
SYSTEM COST: $ 184841.00

TOTAL LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	16563601.	2665407.	2665407.	2665407.	2665407.
INSTALLATION	0.	0.	16817100.	2706200.	2706200.
NONRECURRING	0.	0.	20929234.	141104.	74499.
RECURRING	0.	0.	1500024.	1606881.	1719177.
TOTAL LOGISTIC	0.	0.	22429258.	1747985.	1793687.
TOTAL PROGRAM	16563601.	2665407.	41911768.	7119592.	7165294.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	[illegible]	4569270.	4759656.	4569270.	4950042.
INSTALLATION	[illegible]	2706200.	2899500.	4639200.	4832500.
NONRECURRING	145636.	160733.	141250.	200102.	202430.
RECURRING	2016420.	2128058.	2248257.	2533054.	2734349.
TOTAL LOGISTIC	2162056.	2288791.	2389507.	2733156.	2936779.
TOTAL PROGRAM	7724049.	9564261.	10048662.	11941626.	12719320.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	4950042.	3617338.	3807725.	3617338.	4188497.
INSTALLATION	4639200.	5025800.	5025800.	3672700.	3866000.
NONRECURRING	192939.	282481.	221656.	178091.	185474.
RECURRING	2922776.	3315996.	3519931.	3766397.	3929574.
TOTAL LOGISTIC	3115716.	3598477.	3741587.	3944488.	4115048.
TOTAL PROGRAM	12704957.	12241616.	12575112.	11234526.	12169545.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	3807725.	3998111.	3998111.	3807725.	3426952.
INSTALLATION	3672700.	4252600.	3866000.	4059300.	4059300.
NONRECURRING	186089.	180499.	180477.	239777.	319133.
RECURRING	4079961.	4437631.	4595435.	4770010.	5081261.
TOTAL LOGISTIC	4266050.	4618130.	4775913.	5009787.	5400394.
TOTAL PROGRAM	11746474.	12868840.	12640023.	12876812.	12886646.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
ACQUISITION	0.	0.	0.	0.	0.	88149832.
INSTALLATION	3866000.	3479400.	0.	0.	0.	89497912.
NONRECURRING	232788.	309156.	0.	0.	0.	24703548.
RECURRING	5238212.	5469092.	5469092.	5469092.	5469092.	84019800.
TOTAL LOGISTIC	5471001.	5778249.	5469092.	5469092.	5469092.	108723336.
TOTAL PROGRAM	9337001.	9257649.	5469092.	5469092.	5469092.	286370080.

CUMULATIVE LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	16563601.	19229008.	21894416.	24559824.	27225232.
INSTALLATION	0.	0.	16817100.	19523300.	22229500.
NONRECURRING	0.	0.	20929234.	21070338.	21144838.
RECURRING	0.	0.	1500024.	3106905.	4826092.
TOTAL LOGISTIC	0.	0.	22429258.	24177242.	25970928.
TOTAL PROGRAM	16563601.	19229008.	61140776.	68260368.	75425664.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	30081026.	34650296.	39409952.	43979220.	48929260.
INSTALLATION	24935700.	27641900.	30541400.	35180600.	40013100.
NONRECURRING	21290474.	21451208.	21592458.	21792560.	21994990.
RECURRING	6842512.	8970569.	11218826.	13751080.	16486229.
TOTAL LOGISTIC	28132984.	30421776.	32811282.	35544436.	38481216.
TOTAL PROGRAM	83149712.	92713976.	102762640.	114704264.	127423584.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	53879300.	57496640.	61304364.	64921704.	69110200.
INSTALLATION	44652300.	49678100.	54703900.	58376600.	62242600.
NONRECURRING	22187930.	22470412.	22692068.	22870158.	23055632.
RECURRING	19409006.	22725002.	26244932.	30011330.	33940904.
TOTAL LOGISTIC	41596932.	45195408.	48936996.	52881404.	56996532.
TOTAL PROGRAM	140128544.	152370176.	164945296.	176179824.	188349360.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	72917928.	76916040.	80914152.	84721880.	88148832.
INSTALLATION	65915300.	70167904.	74033904.	78093208.	82152512.
NONRECURRING	23241720.	23422218.	23602696.	23842472.	24161604.
RECURRING	38020864.	42458496.	47053932.	51823944.	56905204.
TOTAL LOGISTIC	61262580.	65880708.	70656624.	75666408.	81066800.
TOTAL PROGRAM	200095840.	212964688.	225604720.	238481536.	251368192.

COST CATEGORY	2005	2006	2007	2008	2009
ACQUISITION	88148832.	88148832.	88148832.	88148832.	88148832.
INSTALLATION	86018512.	89497912.	89497912.	89497912.	89497912.
NONRECURRING	24394392.	24703548.	24703548.	24703548.	24703548.
RECURRING	62143416.	67612512.	73081600.	78550704.	84019800.
TOTAL LOGISTIC	86537800.	92316048.	97785144.	103254240.	108723336.
TOTAL PROGRAM	260705200.	269962848.	275831936.	280901024.	286370112.

SYSTEM TYPE: SCHLS-RKAZ (180)

AL MAINTENANCE HOURS AND LABOR COSTS

1985

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1986

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1987

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	858.	3.54	12509.
PREVENTIVE MAINT	165.	0.68	11040.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1023.	4.22	23549.
BASE LEVEL REPAIR	101.	0.06	1756.
DEPOT LEVEL REPAIR	5.	0.00	109.
TOTAL SYSTEM MAINT	1129.		25415.

1988

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1036.	4.27	15109.
PREVENTIVE MAINT	202.	0.83	11575.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1238.	5.10	26684.
BASE LEVEL REPAIR	123.	0.07	2147.
DEPOT LEVEL REPAIR	6.	0.00	134.
TOTAL SYSTEM MAINT	1368.		28964.

1989

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1125.	4.64	16403.
PREVENTIVE MAINT	220.	0.91	11843.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1345.	5.54	28246.
BASE LEVEL REPAIR	134.	0.08	2342.
DEPOT LEVEL REPAIR	7.	0.00	146.
TOTAL SYSTEM MAINT	1487.		30734.

1990

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1302.	5.36	18983.
PREVENTIVE MAINT	257.	1.06	12378.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1559.	6.42	31361.
BASE LEVEL REPAIR	157.	0.09	2732.
DEPOT LEVEL REPAIR	8.	0.00	170.
TOTAL SYSTEM MAINT	1724.		34264.

1991

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1478.	6.09	21554.
PREVENTIVE MAINT	294.	1.21	12913.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1772.	7.30	34467.
BASE LEVEL REPAIR	179.	0.10	3122.
DEPOT LEVEL REPAIR	9.	0.01	195.
TOTAL SYSTEM MAINT	1960.		37783.

1992

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1654.	6.82	24116.
PREVENTIVE MAINT	330.	1.36	13448.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1984.	8.18	37564.
BASE LEVEL REPAIR	202.	0.11	3513.
DEPOT LEVEL REPAIR	11.	0.01	219.
TOTAL SYSTEM MAINT	2196.		41295.

1993

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1829.	7.54	26671.
PREVENTIVE MAINT	367.	1.51	13983.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2196.	9.05	40654.
BASE LEVEL REPAIR	224.	0.13	3903.
DEPOT LEVEL REPAIR	12.	0.01	243.
TOTAL SYSTEM MAINT	2432.		44800.

1994

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2004.	8.26	29221.
PREVENTIVE MAINT	404.	1.66	14518.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2408.	9.92	43739.
BASE LEVEL REPAIR	246.	0.14	4293.
DEPOT LEVEL REPAIR	13.	0.01	268.
TOTAL SYSTEM MAINT	2667.		48300.

1995

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2179.	8.98	31765.
PREVENTIVE MAINT	440.	1.81	15054.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2619.	10.79	46819.
BASE LEVEL REPAIR	269.	0.15	4683.
DEPOT LEVEL REPAIR	14.	0.01	292.
TOTAL SYSTEM MAINT	2902.		51794.

1996

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2353.	9.70	34306.
PREVENTIVE MAINT	477.	1.97	15589.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2830.	11.66	49894.
BASE LEVEL REPAIR	291.	0.16	5074.
DEPOT LEVEL REPAIR	15.	0.01	316.
TOTAL SYSTEM MAINT	3136.		55284.

1997

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2527.	10.41	36842.
PREVENTIVE MAINT	514.	2.12	16124.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3040.	12.53	52966.
BASE LEVEL REPAIR	314.	0.18	5464.
DEPOT LEVEL REPAIR	17.	0.01	341.
TOTAL SYSTEM MAINT	3371.		58770.

1998

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2700.	11.13	39375.
PREVENTIVE MAINT	551.	2.27	16659.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3251.	13.40	56034.
BASE LEVEL REPAIR	336.	0.19	5854.
DEPOT LEVEL REPAIR	18.	0.01	365.
TOTAL SYSTEM MAINT	3605.		62253.

1999

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2874.	11.84	41905.
PREVENTIVE MAINT	587.	2.42	17194.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3461.	14.26	59099.
BASE LEVEL REPAIR	358.	0.20	6244.
DEPOT LEVEL REPAIR	19.	0.01	389.
TOTAL SYSTEM MAINT	3838.		65733.

2000

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3047.	12.56	44432.
PREVENTIVE MAINT	624.	2.57	17729.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3671.	15.13	62161.
BASE LEVEL REPAIR	381.	0.22	6635.
DEPOT LEVEL REPAIR	20.	0.01	414.
TOTAL SYSTEM MAINT	4072.		69209.

2001

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3220.	13.27	46956.
PREVENTIVE MAINT	661.	2.72	18264.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3881.	15.99	65220.
BASE LEVEL REPAIR	403.	0.23	7025.
DEPOT LEVEL REPAIR	21.	0.01	438.
TOTAL SYSTEM MAINT	4305.		72683.

2002

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3393.	13.98	49478.
PREVENTIVE MAINT	697.	2.87	18800.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4091.	16.86	68278.
BASE LEVEL REPAIR	426.	0.24	7415.
DEPOT LEVEL REPAIR	22.	0.01	462.
TOTAL SYSTEM MAINT	4539.		76155.

2003

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3566.	14.70	51998.
PREVENTIVE MAINT	734.	3.02	19335.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4300.	17.72	71332.
BASE LEVEL REPAIR	448.	0.25	7806.
DEPOT LEVEL REPAIR	24.	0.01	486.
TOTAL SYSTEM MAINT	4772.		79625.

2004

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3739.	15.41	54516.
PREVENTIVE MAINT	771.	3.18	19870.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4509.	18.58	74385.
BASE LEVEL REPAIR	470.	0.27	8196.
DEPOT LEVEL REPAIR	25.	0.01	511.
TOTAL SYSTEM MAINT	5005.		83092.

2005

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3911.	16.12	57031.
PREVENTIVE MAINT	807.	3.33	20405.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4719.	19.45	77436.
BASE LEVEL REPAIR	493.	0.28	8586.
DEPOT LEVEL REPAIR	26.	0.01	535.
TOTAL SYSTEM MAINT	5238.		86558.

2006

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	4084.	16.83	59546.
PREVENTIVE MAINT	844.	3.48	20940.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4929.	20.31	80486.
BASE LEVEL REPAIR	515.	0.29	8976.
DEPOT LEVEL REPAIR	27.	0.02	559.
TOTAL SYSTEM MAINT	5470.		90022.

2007

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	4084.	16.83	59546.
PREVENTIVE MAINT	844.	3.48	20940.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4928.	20.31	80486.
BASE LEVEL REPAIR	515.	0.29	8976.
DEPOT LEVEL REPAIR	27.	0.02	559.
TOTAL SYSTEM MAINT	5470.		90022.

2008

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	4084.	16.83	59546.
PREVENTIVE MAINT	844.	3.48	20940.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4928.	20.31	80486.
BASE LEVEL REPAIR	515.	0.29	8976.
DEPOT LEVEL REPAIR	27.	0.02	559.
TOTAL SYSTEM MAINT	5470.		90022.

2009

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	4084.	16.83	59546.
PREVENTIVE MAINT	844.	3.48	20940.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	4920.	20.31	80486.
BASE LEVEL REPAIR	51[illegible]	0.29	8976.
DEPOT LEVEL REPAIR	27.	0.02	559.
TOTAL SYSTEM MAINT	5470.		90022.

TOTALS

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	61130.	251.91	891351.
PREVENTIVE MAINT	12478.	51.42	380481.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	73608.	303.33	1271032.
BASE LEVEL REPAIR	7617.	4.31	132495.
DEPOT LEVEL REPAIR	401.	0.23	8270.
TOTAL SYSTEM MAINT	81626.		1412797.

SYSTEM TYPE: SCMLS-UAAZ (180)

CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS

1985

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1986

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1987

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	858.	3.54	12509.
PREVENTIVE MAINT	165.	0.68	11040.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1023.	4.22	23549.
BASE LEVEL REPAIR	101.	0.06	1756.
DEPOT LEVEL REPAIR	5.	0.00	109.
TOTAL SYSTEM MAINT	1129.		25415.

1988

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1894.	7.81	27618.
PREVENTIVE MAINT	367.	1.51	22615.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2261.	9.32	50233.
BASE LEVEL REPAIR	224.	0.13	3903.
DEPOT LEVEL REPAIR	12.	0.01	243.
TOTAL SYSTEM MAINT	2497.		54379.

1989

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3019.	12.44	44021.
PREVENTIVE MAINT	587.	2.42	34458.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3606.	14.86	78479.
BASE LEVEL REPAIR	358.	0.20	6244.
DEPOT LEVEL REPAIR	19.	0.01	389.
TOTAL SYSTEM MAINT	3984.		85113.

1990

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	4321.	17.81	63004.
PREVENTIVE MAINT	844.	3.48	46836.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	5165.	21.28	109840.
BASE LEVEL REPAIR	515.	0.29	8976.
DEPOT LEVEL REPAIR	27.	0.02	559.
TOTAL SYSTEM MAINT	5707.		119376.

1991

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	5799.	23.90	84558.
PREVENTIVE MAINT	1138.	4.69	59749.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	6937.	28.59	144307.
BASE LEVEL REPAIR	695.	0.39	12099.
DEPOT LEVEL REPAIR	37.	0.02	734.
TOTAL SYSTEM MAINT	7668.		157140.

1992

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	7453.	30.71	108674.
PREVENTIVE MAINT	1468.	6.05	73197.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	8921.	36.76	181871.
BASE LEVEL REPAIR	896.	0.51	15611.
DEPOT LEVEL REPAIR	47.	0.03	973.
TOTAL SYSTEM MAINT	9864.		198455.

1993

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	9282.	38.25	135345.
PREVENTIVE MAINT	1835.	7.56	87181.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	11117.	45.81	222525.
BASE LEVEL REPAIR	1120.	0.63	19514.
DEPOT LEVEL REPAIR	59.	0.03	1216.
TOTAL SYSTEM MAINT	12296.		243256.

1994

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	11286.	46.51	164565.
PREVENTIVE MAINT	2239.	9.23	101699.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	13525	55.73	266264.
BASE LEVEL REPAIR	1367.	0.77	23807.
DEPOT LEVEL REPAIR	72.	0.04	1484.
TOTAL SYSTEM MAINT	14963.		291555.

1995

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	13465.	55.49	196331.
PREVENTIVE MAINT	2679.	11.04	116753.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16144.	66.53	313083.
BASE LEVEL REPAIR	1635.	0.93	28490.
DEPOT LEVEL REPAIR	86.	0.05	1776.
TOTAL SYSTEM MAINT	17865.		343350.

1996

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	15817.	65.18	230636.
PREVENTIVE MAINT	3156.	13.01	132341.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	18974.	78.19	362978.
BASE LEVEL REPAIR	1927.	1.09	33564.
DEPOT LEVEL REPAIR	101.	0.06	2092.
TOTAL SYSTEM MAINT	21002.		398634.

1997

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	18344.	75.59	267478.
PREVENTIVE MAINT	3670.	15.12	148465.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	22014.	90.72	415944.
BASE LEVEL REPAIR	2240.	1.27	39028.
DEPOT LEVEL REPAIR	118.	0.07	2432.
TOTAL SYSTEM MAINT	24372.		457404.

1998

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	21044.	86.72	306853.
PREVENTIVE MAINT	4221.	17.39	165124.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	25265.	104.11	471977.
BASE LEVEL REPAIR	2576.	1.46	44882.
DEPOT LEVEL REPAIR	136.	0.08	2797.
TOTAL SYSTEM MAINT	27977.		519657.

1999

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	23918.	98.56	348758.
PREVENTIVE MAINT	4800.	19.81	182318.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	28726.	118.38	531075.
BASE LEVEL REPAIR	2935.	1.66	51127.
DEPOT LEVEL REPAIR	154.	0.09	3186.
TOTAL SYSTEM MAINT	31815.		585390.

2000

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	26965.	111.12	393190.
PREVENTIVE MAINT	5432.	22.38	200048.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	32397.	133.50	593237.
BASE LEVEL REPAIR	3316.	1.88	57761.
DEPOT LEVEL REPAIR	175.	0.10	3600.
TOTAL SYSTEM MAINT	35887.		654599.

2001

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	30186.	124.39	440146.
PREVENTIVE MAINT	6092.	25.11	218312.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	36278.	149.50	658458.
BASE LEVEL REPAIR	3719.	2.10	64787.
DEPOT LEVEL REPAIR	196.	0.11	4038.
TOTAL SYSTEM MAINT	40193.		727282.

2002

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	33579.	138.38	489624.
PREVENTIVE MAINT	6790.	27.98	237111.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	40369.	166.35	726735.
BASE LEVEL REPAIR	4145.	2.34	72202.
DEPOT LEVEL REPAIR	218.	0.12	4500.
TOTAL SYSTEM MAINT	44731.		803437.

2003

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	37145.	153.07	541622.
PREVENTIVE MAINT	7524.	31.00	256446.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	44669.	184.07	798068.
BASE LEVEL REPAIR	4573.	2.60	80007.
DEPOT LEVEL REPAIR	242.	0.14	4986.
TOTAL SYSTEM MAINT	49503.		883062.

2004

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	40884.	168.48	596137.
PREVENTIVE MAINT	8294.	34.18	276316.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	49178.	202.66	872453.
BASE LEVEL REPAIR	5063.	2.86	88203.
DEPOT LEVEL REPAIR	266.	0.15	5497.
TOTAL SYSTEM MAINT	54508.		966154.

2005

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	44795.	184.60	653169.
PREVENTIVE MAINT	9102.	37.51	296721.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	53897.	222.10	949890.
BASE LEVEL REPAIR	5556.	3.14	96790.
DEPOT LEVEL REPAIR	292.	0.17	6032.
TOTAL SYSTEM MAINT	59745.		1052711.

2006

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	48879.	201.42	712714.
PREVENTIVE MAINT	9946.	40.99	317661.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	58825.	242.41	1030375.
BASE LEVEL REPAIR	6071.	3.43	105766.
DEPOT LEVEL REPAIR	320.	0.18	6592.
TOTAL SYSTEM MAINT	65216.		1142733.

2007

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	52963.	218.25	772260.
PREVENTIVE MAINT	10790.	44.46	338601.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	63752.	262.72	1110861.
BASE LEVEL REPAIR	6587.	3.73	114742.
DEPOT LEVEL REPAIR	347.	0.20	7151.
TOTAL SYSTEM MAINT	70686.		1232754.

2008

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	57046.	235.08	831806.
PREVENTIVE MAINT	11634.	47.94	359541.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	68680.	283.02	1191346.
BASE LEVEL REPAIR	7102.	4.02	123719.
DEPOT LEVEL REPAIR	374.	0.21	7711.
TOTAL SYSTEM MAINT	76156.		1322776.

2009

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	61130.	251.91	891351.
PREVENTIVE MAINT	12470.	51.42	380481.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	73600.	303.33	1271832.
BASE LEVEL REPAIR	7617.	4.31	134655.
DEPOT LEVEL REPAIR	401.	0.23	8270.
TOTAL SYSTEM MAINT	81675.		1412797.

SYSTEM: SCMLS-DKAZ (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

NONRECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989	
SPARES	0.	0.	1959513.	33899.	1017.	
SHIPPING	0.	0.	4953.	1101.	550.	
INVENTORY MGT	0.	0.	0.	0.	0.	
SUPPORT EQUIP	0.	0.	190000.	0.	0.	
TRAINING	0.	0.	9450.	1450.	0.	
DATA MANAGEMENT	0.	0.	0.	0.	0.	
FACILITIES	0.	0.	0.	0.	0.	
ANNUAL TOTAL	0.	0.	2163916.	36450.	1567.	
COST CATEGORY	1990	1991	1992	1993	1994	
SPARES	9223.	2268.	4415.	4625.	7128.	
SHIPPING	1101.	1101.	1101.	1101.	1101.	
INVENTORY MGT	0.	0.	0.	0.	0.	
SUPPORT EQUIP	0.	0.	0.	0.	0.	
TRAINING	1450.	1450.	1450.	1450.	0.	
DATA MANAGEMENT	0.	0.	0.	0.	0.	
FACILITIES	0.	0.	0.	0.	0.	
ANNUAL TOTAL	11774.	4819.	6966.	7176.	8229.	
COST CATEGORY	1995	1996	1997	1998	1999	
SPARES	2284.	35797.	7598.	2010.	1017.	
SHIPPING	1101.	1101.	1101.	1101.	1101.	
INVENTORY MGT	0.	0.	0.	0.	0.	
SUPPORT EQUIP	0.	0.	0.	0.	0.	
TRAINING	1450.	1450.	1450.	1450.	1450.	
DATA MANAGEMENT	0.	0.	0.	0.	0.	
FACILITIES	0.	0.	0.	0.	0.	
ANNUAL TOTAL	4835.	38348.	10149.	4561.	3568.	
COST CATEGORY	2000	2001	2002	2003	2004	
SPARES	6733.	8816.	217.	1205.	38236.	
SHIPPING	1101.	1101.	1101.	1101.	1101.	
INVENTORY MGT	0.	0.	0.	0.	0.	
SUPPORT EQUIP	0.	0.	0.	0.	0.	
TRAINING	1450.	0.	1450.	1450.	1450.	
DATA MANAGEMENT	0.	0.	0.	0.	0.	
FACILITIES	0.	0.	0.	0.	0.	
ANNUAL TOTAL	9284.	9917.	2768.	3756.	40787.	
COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	10169.	1419.	0.	0.	0.	2137589.
SHIPPING	1101.	1101.	0.	0.	0.	25314.
INVENTORY MGT	0.	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.	190000.
TRAINING	1450.	1450.	0.	0.	0.	32650.
DATA MANAGEMENT	0.	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.	0.
ANNUAL TOTAL	12720.	3970.	0.	0.	0.	2385551.

SYSTEM: BCMLB-PRAZ (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR10.00

RECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	127972.	128372.	127477.
ON-SITE MAINT	0.	0.	25486.	29051.	30828.
OFF-SITE MAINT	0.	0.	4521.	[illegible]	6028.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	2.	3.	3.
TRAINING	0.	0.	945.	1090.	1090.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	0.	0.	2779.	3396.	3705.
ANNUAL TOTAL	0.	0.	161704.	167478.	171131.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	130094.	130654.	133714.	134194.	135139.
ON-SITE MAINT	34374.	37910.	41437.	44958.	48473.
OFF-SITE MAINT	7032.	8037.	9041.	10046.	11051.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	4.	4.	5.	5.	6.
TRAINING	1235.	1380.	1525.	1470.	1470.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	4322.	4940.	5557.	6175.	6792.
ANNUAL TOTAL	177061.	182925.	191280.	197048.	203131.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	135619.	136396.	136796.	137599.	138079.
ON-SITE MAINT	51984.	55489.	58991.	62490.	65985.
OFF-SITE MAINT	12055.	13060.	14064.	15069.	16074.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	6.	7.	7.	8.	9.
TRAINING	1815.	1960.	2105.	2250.	2395.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	7410.	8027.	8645.	9262.	9880.
ANNUAL TOTAL	208889.	214939.	220609.	226678.	232421.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	141059.	141619.	142316.	142876.	143493.
ON-SITE MAINT	69477.	72967.	76455.	79940.	83423.
OFF-SITE MAINT	17078.	18083.	19087.	20092.	21097.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	9.	10.	10.	11.	11.
TRAINING	2540.	2540.	2685.	2830.	2975.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	10497.	11115.	11732.	12350.	12967.
ANNUAL TOTAL	240661.	246333.	252285.	258098.	263966.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	144301.	145239.	145239.	145239.	145239.	3170725.
ON-SITE MAINT	84905.	90384.	90384.	90384.	90384.	1418162.
OFF-SITE MAINT	22101.	23106.	23106.	23106.	23106.	341563.
INVENTORY MGT	0.	0.	0.	0.	0.	0.
SUPPORT EQUIP	12.	12.	12.	12.	12.	181.
TRAINING	3120.	3265.	3265.	3265.	3265.	50880.
DATA MANAGEMENT	0.	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.	0.
SITE OPERATION	13585.	14202.	14202.	14202.	14202.	209943.
ANNUAL TOTAL	270023.	276208.	276208.	276208.	276208.	5191453.

SYSTEM: SC/LS-PRAZ (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00
SYSTEM COSTS $ 68152.00

TOTAL LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	631769.	140393.	70197.	140393.	140393.
INSTALLATION	0.	0.	124200.	27600.	13800.
NONRECURRING	0.	0.	2163916.	36450.	1567.
RECURRING	0.	0.	161704.	167438.	171131.
TOTAL LOGISTIC	0.	0.	2325620.	203887.	172698.
TOTAL PROGRAM	631769.	140393.	2520017.	371880.	326892.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	140393.	140393.	140393.	140393.	140393.
INSTALLATION	27600.	27600.	27600.	27600.	27600.
NONRECURRING	11774.	4819.	6966.	7176.	8229.
RECURRING	177061.	182925.	191280.	197048.	203131.
TOTAL LOGISTIC	180835.	187743.	198245.	204224.	211360.
TOTAL PROGRAM	356820.	355736.	366239.	372217.	379353.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	140393.	140393.	140393.	140393.	140393.
INSTALLATION	27600.	27600.	27600.	27600.	27600.
NONRECURRING	4835.	38348.	10149.	4561.	3568.
RECURRING	208889.	214939.	220609.	226678.	232421.
TOTAL LOGISTIC	213723.	253287.	230757.	231238.	235988.
TOTAL PROGRAM	381717.	421280.	398750.	399232.	403981.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	140393.	140393.	140393.	140393.	140393.
INSTALLATION	27600.	27600.	27600.	27600.	27600.
NONRECURRING	9284.	9917.	2768.	3756.	40787.
RECURRING	240661.	246333.	252285.	258098.	263966.
TOTAL LOGISTIC	249944.	256250.	255053.	261854.	304753.
TOTAL PROGRAM	417938.	424243.	423046.	429847.	472746.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
ACQUISITION	0.	0.	0.	0.	0.	3229041.
INSTALLATION	27600.	27600.	0.	0.	0.	634800.
NONRECURRING	12720.	3970.	0.	0.	0.	2385551.
RECURRING	270023.	276208.	276208.	276208.	276208.	5191455.
TOTAL LOGISTIC	282743.	280178.	276208.	276208.	276208.	7577009.
TOTAL PROGRAM	310343.	307778.	276208.	276208.	276208.	11440848.

CUMULATIVE LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	631769.	772162.	842359.	982752.	1123145.
INSTALLATION	0.	0.	124200.	151800.	165600.
NONRECURRING	0.	0.	2163916.	2200365.	2201933.
RECURRING	0.	0.	161704.	329142.	500273.
TOTAL LOGISTIC	0.	0.	2325620.	2529507.	2702206.
TOTAL PROGRAM	631769.	772162.	3292179.	3664059.	3990951.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	1263538.	1403931.	1544324.	1684717.	1825111.
INSTALLATION	193200.	220800.	248400.	276000.	303600.
NONRECURRING	2213706.	2218525.	2225490.	2232666.	2240894.
RECURRING	677334.	860259.	1051539.	1248587.	1451718.
TOTAL LOGISTIC	2891041.	3078784.	3277029.	3481253.	3692613.
TOTAL PROGRAM	4347779.	4703515.	5069753.	5441970.	5821323.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	1965504.	2105897.	2246290.	2386683.	2527076.
INSTALLATION	331200.	358800.	386400.	414000.	441600.
NONRECURRING	2245729.	2284076.	2294225.	2298785.	2302353.
RECURRING	1660607.	1875546.	2096155.	2322833.	2555254.
TOTAL LOGISTIC	3906337.	4159623.	4390381.	4621619.	4857608.
TOTAL PROGRAM	6203039.	6624319.	7023070.	7422301.	7826283.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	2667469.	2807862.	2948255.	3088648.	3229041.
INSTALLATION	469200.	496800.	524400.	552000.	579600.
NONRECURRING	2311636.	2321553.	2324320.	2328076.	2368862.
RECURRING	2795914.	3042248.	3294533.	3552631.	3816598.
TOTAL LOGISTIC	5107552.	5363802.	5618855.	5880709.	6185462.
TOTAL PROGRAM	8244220.	8668463.	9091509.	9521356.	9994102.

COST CATEGORY	2005	2006	2007	2008	2009
ACQUISITION	3229041.	3229041.	3229041.	3229041.	3229041.
INSTALLATION	607200.	634800.	634800.	634800.	634800.
NONRECURRING	2381582.	2385551.	2385551.	2385551.	2385551.
RECURRING	4086621.	4362829.	4639038.	4915246.	5191455.
TOTAL LOGISTIC	6468205.	6748383.	7024592.	7300800.	7577009.
TOTAL PROGRAM	10304445.	10612223.	10888431.	11164639.	11440847.

SYSTEM TYPE: BASIC I (180)

ANNUAL MAINTENANCE HOURS AND LABOR COSTS

	1985			1986			1987		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.	0.	0.00	0.	2125.	8.76	30980.
PREVENTIVE MAINT	0.	0.00	0.	0.	0.00	0.	92.	0.38	9970.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.	0.	0.00	0.	2216.	9.13	40949.
BASE LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	370.	0.21	6446.
DEPOT LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	19.	0.01	399.
TOTAL SYSTEM MAINT	0.		0.	0.		0.	2606.		47795.

	1988			1989			1990		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	15323.	63.14	223427.	27603.	113.75	402493.	40245.	165.84	586816.
PREVENTIVE MAINT	697.	2.87	18800.	1266.	5.22	27094.	1853.	7.64	35656.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	16020.	66.02	242226.	28870.	118.97	429507.	42098.	173.48	622472.
BASE LEVEL REPAIR	2812.	1.59	48993.	5107.	2.89	88960.	7475.	4.23	130217.
DEPOT LEVEL REPAIR	147.	0.08	3033.	267.	0.15	5507.	391.	0.22	8061.
TOTAL SYSTEM MAINT	18980.		294252.	34243.		524055.	49964.		760751.

	1991			1992			1993		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	52077.	214.60	759354.	65080.	268.19	940952.	74530.	307.13	1086747.
PREVENTIVE MAINT	2404.	9.91	43683.	3009.	12.40	52513.	3450.	14.22	58934.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	54481.	224.51	803037.	68090.	280.59	1001464.	77980.	321.35	1145682.
BASE LEVEL REPAIR	9695.	5.48	168896.	12138.	6.87	211442.	13914.	7.87	242385.
DEPOT LEVEL REPAIR	507.	0.29	10456.	635.	0.36	13090.	727.	0.41	15005.
TOTAL SYSTEM MAINT	64684.		982388.	80862.		1225996.	92622.		1403072.

	1994			1995			1996		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	84763.	349.30	1235956.	94599.	389.03	1379369.	104431.	430.35	1522735.
PREVENTIVE MAINT	3927.	16.18	65891.	4386.	18.07	72580.	4844.	19.96	79269.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	88690.	365.48	1301847.	98984.	407.90	1451949.	109275.	450.31	1602004.
BASE LEVEL REPAIR	15838.	8.96	275906.	17689.	10.00	308138.	19539.	11.05	340370.
DEPOT LEVEL REPAIR	828.	0.47	17080.	925.	0.52	19076.	1021.	0.58	21071.
TOTAL SYSTEM MAINT	105357.		1594833.	117598.		1779163.	129836.		1963445.

	1997			1998			1999		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	114654.	472.47	1671792.	122515.	504.67	1786426.	127590.	534.02	1889579.
PREVENTIVE MAINT	5322.	21.93	86226.	5689.	23.44	91577.	6019.	24.80	96394.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	119975.	494.40	1758019.	128204.	528.31	1878003.	135608.	558.83	1985972.
BASE LEVEL REPAIR	21463.	12.14	373891.	22943.	12.98	399677.	24275.	13.73	422894.
DEPOT LEVEL REPAIR	1122.	0.63	23146.	1199.	0.68	24743.	1269.	0.72	26179.
TOTAL SYSTEM MAINT	142560.		2155056.	152347.		2302423.	161153.		2435036.

	2000			2001			2002		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	137842.	568.03	2009904.	144914.	597.17	2113026.	151985.	626.31	2216134.
PREVENTIVE MAINT	6404.	26.39	102013.	6734.	27.75	106829.	7065.	29.11	111645.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	144246.	594.42	2111917.	151648.	624.92	2219354.	159050.	655.43	2327779.
BASE LEVEL REPAIR	25830.	14.61	449959.	2716[illegible].	15.36	473166.	28494.	16.12	496373.
DEPOT LEVEL REPAIR	1350.	0.76	27855.	1420.	0.80	29292.	1490.	0.84	30729.
TOTAL SYSTEM MAINT	171426.		2589731.	180230.		2722312.	189034.		2854881.

	2003			2004			2005		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	159841.	658.69	2330685.	167304.	689.44	2439496.	174765.	720.19	2548296.
PREVENTIVE MAINT	7432.	30.63	116996.	7780.	32.06	122080.	8129.	33.50	127164.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	167273.	689.31	2447682.	175084.	721.50	2561576.	182894.	753.69	2675460.
BASE LEVEL REPAIR	29974.	16.95	522158.	31381.	17.75	546655.	32787.	18.54	571151.
DEPOT LEVEL REPAIR	1567.	0.89	32325.	1641.	0.93	33842.	1714.	0.97	35358.
TOTAL SYSTEM MAINT	198814.		3002165.	208105.		3142072.	217395.		3281769.

	2006			2007			2008		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	183011.	754.17	2668535.	183011.	754.17	2668535.	183011.	754.17	2668535.
PREVENTIVE MAINT	8514.	35.09	132783.	8514.	35.09	132783.	8514.	35.09	132783.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	191526.	789.25	2801318.	191526.	789.25	2801318.	191526.	789.25	2801318.
BASE LEVEL REPAIR	34341.	19.42	598226.	34341.	19.42	598226.	34341.	19.42	598226.
DEPOT LEVEL REPAIR	1795.	1.02	37034.	1795.	1.02	37034.	1795.	1.02	37034.
TOTAL SYSTEM MAINT	227662.		3436578.	227662.		3436578.	227662.		3436578.

	2009			TOTALS		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	183011.	754.17	2668535.	2596232.	10698.76	37856308.
PREVENTIVE MAINT	8514.	35.09	132783.	120559.	496.01	1956445.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	191526.	789.25	2801318.	2716791.	11195.5[illegible]	39812748.
BASE LEVEL REPAIR	34341.	19.42	598226.	486250.	275.03	8470571.
DEPOT LEVEL REPAIR	1795.	1.02	37034.	25421.	14.38	524385.
TOTAL SYSTEM MAINT	227662.		3436578.	3228462.		48807700.

SYSTEM TYPE: BASIC 1 (180)

CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS

1985

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1986

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1987

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	[illegible]	[illegible]	[illegible]
PREVENTIVE MAINT	[illegible]	[illegible]	[illegible]
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2216.	9.13	40949.
BASE LEVEL REPAIR	370.	0.21	6446.
DEPOT LEVEL REPAIR	19.	0.01	[illegible]
TOTAL SYSTEM MAINT	2606.		47795.

1988

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1744[illegible].	71.90	254406.
PREVENTIVE MAINT	789.	3.25	28769.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1823[illegible].	75.15	283176.
BASE LEVEL REPAIR	3182.	1.83	55439.
DEPOT LEVEL REPAIR	166.	0.09	3432.
TOTAL SYSTEM MAINT	21585.		342047.

1989

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	45051.	185.65	656899.
PREVENTIVE MAINT	2055.	8.47	55863.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	47106.	194.12	712763.
BASE LEVEL REPAIR	8289.	4.69	144399.
DEPOT LEVEL REPAIR	433.	0.25	8939.
TOTAL SYSTEM MAINT	55829.		866101.

1990

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	85296.	351.49	1243715.
PREVENTIVE MAINT	3909.	16.11	91520.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	89204.	367.60	1335235.
BASE LEVEL REPAIR	15764.	8.92	274617.
DEPOT LEVEL REPAIR	824.	0.47	17001.
TOTAL SYSTEM MAINT	105792.		1626852.

1991

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	137373.	566.10	2003069.
PREVENTIVE MAINT	6312.	26.01	135203.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	143685.	592.11	2138272.
BASE LEVEL REPAIR	25460.	14.40	443512.
DEPOT LEVEL REPAIR	1331.	0.75	27456.
TOTAL SYSTEM MAINT	170476.		2609240.

1992

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	202453.	834.29	2952020.
PREVENTIVE MAINT	9322.	38.41	187716.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	211775.	872.70	3139736.
BASE LEVEL REPAIR	37597.	21.27	654954.
DEPOT LEVEL REPAIR	1966.	1.11	40546.
TOTAL SYSTEM MAINT	251338.		3835236.

1993

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	276984.	1141.42	4038768.
PREVENTIVE MAINT	12772.	52.63	246650.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	289755.	1194.05	4285418.
BASE LEVEL REPAIR	51511.	29.14	897339.
DEPOT LEVEL REPAIR	2693.	1.52	5555[illegible].
TOTAL SYSTEM MAINT	343960.		5238308.

1994

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	361747.	1490.72	5274724.
PREVENTIVE MAINT	16699.	68.81	312541.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	378445.	1559.53	5587265.
BASE LEVEL REPAIR	673[illegible]0.	38.09	1173245.
DEPOT LEVEL REPAIR	3521.	1.99	72632.
TOTAL SYSTEM MAINT	449316.		6833141.

1995

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	456346.	1880.55	6654093.
PREVENTIVE MAINT	21084.	86.89	385121.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	477430.	1967.43	7039214.
BASE LEVEL REPAIR	85038.	48.10	1481383.
DEPOT LEVEL REPAIR	4446.	2.51	91707.
TOTAL SYSTEM MAINT	566914.		8612304.

1996

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	560777.	2310.89	8176827.
PREVENTIVE MAINT	25929.	106.85	464391.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	586705.	2417.74	8641218.
BASE LEVEL REPAIR	104577.	59.15	1821753.
DEPOT LEVEL REPAIR	5467.	3.09	112779.
TOTAL SYSTEM MAINT	696750.		10575749.

1997

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	6754[illegible].	2783.37	9848619.
PREVENTIVE MAINT	31250.	128.78	550617.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	706680.	2912.14	10399237.
BASE LEVEL REPAIR	126040.	71.29	2195644.
DEPOT LEVEL REPAIR	6589.	3.73	135925.
TOTAL SYSTEM MAINT	839310.		12730805.

1998

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	797946.	3288.24	11635045.
PREVENTIVE MAINT	36939.	152.22	642194.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	834884.	3440.46	12277240.
BASE LEVEL REPAIR	148903.	84.27	2595321.
DEPOT LEVEL REPAIR	7789.	4.41	160668.
TOTAL SYSTEM MAINT	991656.		15033228.

1999

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	927535.	3822.26	13524624.
PREVENTIVE MAINT	42957.	177.02	738588.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	970493.	3999.28	14263212.
BASE LEVEL REPAIR	173259.	98.00	3018205.
DEPOT LEVEL REPAIR	9058.	5.12	186847.
TOTAL SYSTEM MAINT	1152809.		17468264.

2000

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1065377.	4390.29	15534528.
PREVENTIVE MAINT	49362.	203.41	840600.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1114738.	4593.70	16375129.
BASE LEVEL REPAIR	199089.	112.61	3468163.
DEPOT LEVEL REPAIR	10408.	5.89	214702.
TOTAL SYSTEM MAINT	1324235.		20057996.

2001

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1210291.	4987.46	17647554.
PREVENTIVE MAINT	56096.	231.16	947429.
CALL-BACK MAINT	[illegible].	0.00	0.
TOTAL SITE MAINT	12663[illegible].	5218.63	18594984.
BASE LEVEL REPAIR	22625[illegible]	127.97	[illegible]941329.
DEPOT LEVEL REPAIR	11829.	6.69	243995.
TOTAL SYSTEM MAINT	1504466.		22780300.

2002

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1362276.	5613.77	19863688.
PREVENTIVE MAINT	63161.	260.28	1059074.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1425437.	5874.05	20922764.
BASE LEVEL REPAIR	254745.	144.09	4437702.
DEPOT LEVEL REPAIR	13318.	7.53	274723.
TOTAL SYSTEM MAINT	1693499.		25635188.

2003

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1522117.	6272.46	22194374.
PREVENTIVE MAINT	70592.	290.90	1176070.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1592710.	6563.36	23370446.
BASE LEVEL REPAIR	284719.	161.04	4959861.
DEPOT LEVEL REPAIR	14885.	8.42	307048.
TOTAL SYSTEM MAINT	1892314.		28637354.

2004

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1689421.	6961.90	24633870.
PREVENTIVE MAINT	78373.	322.97	1298150.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1767794.	7284.86	25932022.
BASE LEVEL REPAIR	316100.	1[illegible]8.79	5506516.
DEPOT LEVEL REPAIR	16525.	9.35	340890.
TOTAL SYSTEM MAINT	2100419.		31779426.

2005

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1864186.	7682.09	27182166.
PREVENTIVE MAINT	86502.	356.46	1425314.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1950688.	8038.55	28607482.
BASE LEVEL REPAIR	348886.	197.33	6077667.
DEPOT LEVEL REPAIR	18239.	10.32	376248.
TOTAL SYSTEM MAINT	2317814.		35061396.

2006

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2047198.	8436.25	29850702.
PREVENTIVE MAINT	95016.	391.55	1558097.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2142214.	8827.80	31408800.
BASE LEVEL REPAIR	383227.	216.76	6675893.
DEPOT LEVEL REPAIR	20035.	11.33	413282.
TOTAL SYSTEM MAINT	254547[illegible].		38497972.

2007

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2230209.	9190.42	32519238.
PREVENTIVE MAINT	103531.	426.64	1690879.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2333740.	9617.06	34210116.
BASE LEVEL REPAIR	417568.	236.18	7274119.
DEPOT LEVEL REPAIR	21830.	12.35	450316.
TOTAL SYSTEM MAINT	2773138.		41934548.

2008

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2413221.	9944.59	35187772.
PREVENTIVE MAINT	112045.	461.72	1823662.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2525265.	10406.31	37011432.
BASE LEVEL REPAIR	451909.	255.60	7872345.
DEPOT LEVEL REPAIR	23625.	13.36	487351.
TOTAL SYSTEM MAINT	3000800.		45371124.

2009

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	2596232.	10698.76	37056308.
PREVENTIVE MAINT	120559	496.81	1956445.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	2716791.	11195.57	39012748.
BASE LEVEL REPAIR	486250.	275.03	84[illegible]71.
DEPOT LEVEL REPAIR	25421.	14.38	524385.
TOTAL SYSTEM MAINT	32284[illegible]2.		48807700.

SYSTEM: BASIC I (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR10.00

NONRECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	4055370.	519425.	414354.
SHIPPING	0.	0.	8304.	54804.	51482.
INVENTORY MGT	0.	0.	37200.	0.	0.
SUPPORT EQUIP	0.	0.	97920.	0.	0.
TRAINING	0.	0.	16700.	84850.	77400.
DATA MANAGEMENT	0.	0.	7860000.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	1207549[illegible].	659079.	543436.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	431745.	330951.	612136.	470620	635122.
SHIPPING	53143.	49822.	54804.	39857.	[illegible]
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	84150.	76150.	83400.	61650.	66000.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	569038.	456923.	750340.	572127.	744301.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	553672.	542091.	557055.	463367.	398654.
SHIPPING	41518.	41518.	43179.	33214.	29893.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	65300.	64550.	66000.	49300.	45700.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	660490.	648159.	666234.	545882.	474247.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	479766.	384492.	374295.	521787.	375678.
SHIPPING	34875.	29893.	29893.	33214.	31554.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	54400.	45700.	47150.	49300.	48600.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	569041.	460085.	451338.	604301.	455832.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	396051.	506394.	0.	0.	0.	13023225.
SHIPPING	31554.	34875.	0.	0.	0.	770575.
INVENTORY MGT	0.	0.	0.	0.	0.	37200.
SUPPORT EQUIP	0.	0.	0.	0.	0.	97920.
TRAINING	48600.	54400	0.	0.	0.	1189500.
DATA MANAGEMENT	0.	0.	0.	0.	0.	7860000.
FACILITIES	0.	0.	0.	0.	0.	0.
ANNUAL TOTAL	476205.	595869.	0.	0.	0.	22978430.

SYSTEM: BASIC I (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR10.00

RECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	570486.	783104.	965633.
ON-SITE MAINT	0.	0.	44863.	271973.	463600.
OFF-SITE MAINT	0.	0.	16689.	126839.	230313.
INVENTORY MGT	0.	0.	4650.	4650.	4650.
SUPPORT EQUIP	0.	0.	29.	223.	406.
TRAINING	0.	0.	1670.	10155.	17915.
DATA MANAGEMENT	0.	0.	93600.	93600.	93600.
FACILITIES	0.	0.	78000.	78000.	78000.
SITE OPERATION	0.	0.	8063.	61275.	111263.
ANNUAL TOTAL	0.	0.	818051.	1429819.	1985379.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	1158120.	1519531.	1822901.	2037656.	2180488.
ON-SITE MAINT	701534.	905583.	1129843.	1292847.	1469365.
OFF-SITE MAINT	337125.	437261.	547411.	627520.	714305.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	594.	770.	964.	1105.	1258.
TRAINING	26330.	33945.	42285.	48450.	55050.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	79000.
SITE OPERATION	162863.	211233.	264455.	303150.	345075.
ANNUAL TOTAL	2562816.	3284578.	3984104.	4486979.	4941791.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	2309759.	2676656.	2021784.	2946976.	2215407.
ON-SITE MAINT	1639037.	1808662.	1985030.	2120670.	2242730.
OFF-SITE MAINT	797751.	881198.	967983.	[illegible]	1094822.
INVENTORY MGT	4650.	4650.	4650.	[illegible]	4650.
SUPPORT EQUIP	1405.	1552.	1704.	[illegible]	1928.
TRAINING	61580.	68035.	74635.	[illegible]	84135.
DATA MANAGEMENT	93600.	93600.	93600.	[illegible]	93600.
FACILITIES	78000.	78000.	78000.	[illegible]	78000.
SITE OPERATION	385380.	425700.	467625.	[illegible]	528900.
ANNUAL TOTAL	5451170.	6038053.	6495011.	[illegible]	7344251.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	3368658.	3493244.	3659781.	3907143.	4026596.
ON-SITE MAINT	2385113.	2507141.	2629156.	2764714.	2893482.
OFF-SITE MAINT	1164917.	1224999.	1285081.	1351038.	1415258.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	2051.	2157.	2263.	2380.	2492.
TRAINING	89575.	94145.	98860.	103790.	108650.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	[illegible]	78000.	78000.
SITE OPERATION	562743.	591788.	[illegible]	653063.	683700.
ANNUAL TOTAL	7769327.	8089723.	[illegible]	8959178.	9306428.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	4203082.	4308917.	4308917.	4308917.	4308917.	65002752.
ON-SITE MAINT	3022239.	3164535.	3164535.	3164535.	3164535.	44955724.
OFF-SITE MAINT	1478677.	1548773.	1548773.	1548773.	1548773.	21929818.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.	106950.
SUPPORT EQUIP	2604.	2727.	2727.	2727.	2727.	38613.
TRAINING	113510.	118950.	118950.	118950.	118950.	1688085.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.	2152800.
FACILITIES	78000.	78000.	78000.	78000.	78000.	1794000.
SITE OPERATION	714330.	748200.	748200.	748200.	748200.	10594126.
ANNUAL TOTAL	9710700.	10068352.	10068352.	10068352.	10068352.	148262880.

SYSTEM: BASIC I (100)
UNIT: NATIONAL AIR SPACE
DISCOUNT FACTOR 10.00
SYSTEM COST: $ 361838.00

TOTAL LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	1863466.	12298873.	11553487.	11926180.	11180794.
INSTALLATION	0.	0.	1302000.	8593200.	8072400.
NONRECURRING	0.	0.	12075494.	659079.	543436.
RECURRING	0.	0.	818051.	1429819.	1905379.
TOTAL LOGISTIC	0.	0.	12893545.	2088098.	2528816.
TOTAL PROGRAM	1863466.	12298873.	25749032.	22608278.	21782010.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	12298873.	8944635.	9690021.	9317328.	9317328.
INSTALLATION	8332800.	7812000.	8593200.	6249600.	6770400.
NONRECURRING	569038.	456923.	750340.	572127.	744301.
RECURRING	2562816.	3284578.	3984104.	4486979.	4941791.
TOTAL LOGISTIC	3131854.	3741501.	4734444.	5059106.	5686092.
TOTAL PROGRAM	23763528.	20498136.	23017666.	20626034.	21773820.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	9690021.	7453863.	6708477.	7826556.	6708477.
INSTALLATION	6510000.	6510000.	6770400.	5208000.	4687200.
NONRECURRING	660470.	648159.	666234.	545882.	474247.
RECURRING	5451170.	6038053.	6495011.	6859829.	7344251.
TOTAL LOGISTIC	6111640.	6686212.	7161245.	7405710	7818498.
TOTAL PROGRAM	22311682.	20650076.	20640122.	20440336.	19214176.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	6708477.	7453863.	7081170.	7081170.	7826556.
INSTALLATION	5468400.	4687200.	4687200.	5208000.	4947600.
NONRECURRING	569041.	460085.	451338.	604301.	455832.
RECURRING	77[illegible]9327.	8089723.	8472203.	8959178.	9306428.
TOTAL LOGISTIC	8338368.	8549808.	8923541.	9563479.	9762260.
TOTAL PROGRAM	20515246.	20690872.	20691912.	21852650.	22536416.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
ACQUISITION	0.	0.	0.	0.	0.	172929616.
INSTALLATION	4947600.	5468400.	0.	0.	0.	120825600.
NONRECURRING	476205.	595369.	0.	0.	0.	22978426.
RECURRING	9710700.	10068352.	10068352.	10068352.	10068352.	148262880.
TOTAL LOGISTIC	10186905.	1066422[illegible]	10068352.	10068352.	10068352.	171241296.
TOTAL PROGRAM	15134505.	16132621.	10068352.	10068352.	10068352.	464996480.

CUMULATIVE LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	363466.	14162339.	25715826.	37642008.	48822804.
INSTALLATION	0.	0.	1302000.	9895200.	17967600.
NONRECURRING	0.	0.	12075494.	12734573.	13278009.
RECURRING	0.	0.	818051.	2247870.	4233249.
TOTAL LOGISTIC	0.	0.	12893545.	14982443.	17511258.
TOTAL PROGRAM	1863466.	14162339.	39911372.	62519652.	84301664.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	61121676.	70066312.	79756336.	89073664.	98390992.
INSTALLATION	26300400.	34112400.	42705600.	48955200.	55725600.
NONRECURRING	13847047.	14303970.	15054310.	15626437.	16370738.
RECURRING	6796065.	10080642.	14064746.	18551724.	23493514.
TOTAL LOGISTIC	20643112.	24384612.	29119056.	34178164.	39864256.
TOTAL PROGRAM	108065192.	128563328.	151580992.	172207024.	193980848.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	108081016.	115534880.	122243360.	130069912.	136778384.
INSTALLATION	62235600.	68745600.	75516000.	80724000.	85411200.
NONRECURRING	17031228.	17679388.	18345622.	18891504.	19365752.
RECURRING	28944604.	34982736.	41477748.	48337648.	55681900.
TOTAL LOGISTIC	45975916.	52662128.	59823372.	67229152.	75047648.
TOTAL PROGRAM	216292528.	236942592.	257582720.	278023072.	297237248.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	143486864.	150940720.	158021888.	165103056.	172929616.
INSTALLATION	90879600.	95566800.	100254000.	105462000.	110409600.
NONRECURRING	19934794.	20394880.	20846218.	21450520.	21906352.
RECURRING	63451228.	71540952.	80013152.	88972328.	98278760.
TOTAL LOGISTIC	83386016.	91935824.	100859368.	110422848.	120185112.
TOTAL PROGRAM	317752512.	338443392.	359135328.	380988000.	403524448.

COST CATEGORY	2005	2006	2007	2008	2009
ACQUISITION	172929616.	172929616.	172929616.	172929616.	172929616.
INSTALLATION	115357200.	120825600.	120825600.	120825600.	120825600.
NONRECURRING	22382556.	22978426.	22978426.	22978426.	22978426.
RECURRING	107989464.	118057816.	128126168.	138194529.	148262880.
TOTAL LOGISTIC	130372016.	141036240.	151104592.	161172944.	171241296.
TOTAL PROGRAM	418658976.	434791016.	444859968.	454928320.	464996672.

SYSTEM TYPE: BASIC-BKAX (180)

ANNUAL MAINTENANCE HOURS AND LABOR COSTS

	1985			1986			1987		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.	0.	0.00	0.	245.	1.01	3572.
PREVENTIVE MAINT	0.	0.00	0.	0.	0.00	0.	18.	0.08	8900.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.	0.	0.00	0.	263.	1.09	12471.
BASE LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	34.	0.02	589.
DEPOT LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	2.	0.00	36.
TOTAL SYSTEM MAINT	0.		0.	0.		0.	299.		13096.

	1988			1989			1990		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1483.	6.11	21619.	2684.	11.06	39133.	3874.	15.96	56487.
PREVENTIVE MAINT	128.	0.53	10505.	239.	0.98	12110.	349.	1.44	13716.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	1611.	6.64	32124.	2922.	12.04	51243.	4223.	17.40	70203.
BASE LEVEL REPAIR	237.	0.13	4120.	439.	0.25	7652.	642.	0.36	11183.
DEPOT LEVEL REPAIR	12.	0.01	254.	23.	0.01	473.	33.	0.02	691.
TOTAL SYSTEM MAINT	1860.		36499.	3385.		59368.	4898.		82077.

	1991			1992			1993		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	5058.	20.84	73753.	6238.	25.71	90963.	7220.	29.75	105272.
PREVENTIVE MAINT	459.	1.89	15321.	569.	2.34	16927.	661.	2.72	18264.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	5517.	22.73	89074.	6807.	28.05	107889.	7880.	32.47	123537.
BASE LEVEL REPAIR	845.	0.48	14715.	1047.	0.59	18247.	1216.	0.69	21190.
DEPOT LEVEL REPAIR	44.	0.02	909.	55.	0.03	1127.	63.	0.04	1309.
TOTAL SYSTEM MAINT	6406.		104698.	7909.		127263.	9160.		146035.

	1994			1995			1996		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	8200.	33.79	119559.	9178.	37.82	133827.	10156.	41.85	148080.
PREVENTIVE MAINT	752.	3.10	19602.	844.	3.48	20940.	936.	3.86	22278.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	8952.	36.89	139161.	10022.	41.30	154767.	11091.	45.71	170358.
BASE LEVEL REPAIR	1385.	0.78	24133.	1554.	0.88	27076.	1723.	0.97	30019.
DEPOT LEVEL REPAIR	72.	0.04	1490.	81.	0.05	1672.	90.	0.05	1854.
TOTAL SYSTEM MAINT	10409.		164784.	11657.		183515.	12904.		202231.

	1997			1998			1999		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	11132.	45.87	162319.	11913.	49.09	173702.	12693.	52.31	185079.
PREVENTIVE MAINT	1028.	4.23	23616.	1101.	4.54	24686.	1174.	4.84	25756.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	12160.	50.11	185935.	13014.	53.63	198388.	13867.	57.15	210835.
BASE LEVEL REPAIR	1892.	1.07	32962.	2027.	1.15	35316.	2162.	1.22	37670.
DEPOT LEVEL REPAIR	99.	0.06	2036.	106.	0.06	2161.	113.	0.06	[illegible]
TOTAL SYSTEM MAINT	14150.		220932.	15147.		235805.	16143.		[illegible]

	2000			2001			2002		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	13473.	55.52	196449.	14252.	58.73	207813.	15031.	61.94	219173.
PREVENTIVE MAINT	1248.	5.14	26826.	1321.	5.44	27897.	1395.	5.75	28967.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	14721.	60.66	223275.	15573.	64.18	235710.	16426.	67.69	248140.
BASE LEVEL REPAIR	2298.	1.30	40025.	2433.	1.38	42379.	2568.	1.45	44734.
DEPOT LEVEL REPAIR	120.	0.07	2472.	127.	0.07	2617.	134.	0.08	2763.
TOTAL SYSTEM MAINT	17138.		265772.	18133.		280707.	19128.		295637.

	2003			2004			2005		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	15810.	65.15	230528.	16588.	68.36	241878.	17366.	71.57	253225.
PREVENTIVE MAINT	1468.	6.05	30037.	1541.	6.35	31108.	1615.	6.65	32178.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	17278.	71.20	260565.	18130.	74.71	272986.	18981.	78.22	285403.
BASE LEVEL REPAIR	2703.	1.53	47088.	2838.	1.61	49442.	2973.	1.68	51797.
DEPOT LEVEL REPAIR	141.	0.08	2908.	148.	0.08	3054.	155.	0.09	3199.
TOTAL SYSTEM MAINT	20122.		310561.	21116.		325482.	22110.		340399.

	2006			2007			2008		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	18144.	74.77	264568.	18144.	74.77	264568.	18144.	74.77	[illegible]
PREVENTIVE MAINT	1688.	6.96	33248.	1688.	6.96	33248.	1688.	6.96	[illegible]
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	[illegible]	0.00	0.
TOTAL SITE MAINT	19833.	81.73	297816.	19833.	81.73	297816.	19833.	81.73	297816.
BASE LEVEL REPAIR	3109.	1.76	54151.	3109.	1.76	54151.	3109.	1.76	54151.
DEPOT LEVEL REPAIR	162.	0.09	3344.	162.	0.09	3344.	162.	0.09	3344.
TOTAL SYSTEM MAINT	23103.		355311.	23103.		355311.	23103.		355311

	2009			TOTALS		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	18144.	74.77	264568.	255170.	1051.53	[illegible]
PREVENTIVE MAINT	1688.	6.96	33248.	23598.	97.24	542526.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	19833.	81.73	297816.	278769.	1148.77	4263330.
BASE LEVEL REPAIR	3109.	1.76	54151.	43452.	24.58	756940.
DEPOT LEVEL REPAIR	162.	0.09	3344.	2266.	1.28	46750.
TOTAL SYSTEM MAINT	23103.		355311.	[illegible]		5067019.

SYSTEM TYPE: BASIC-BAAZ (180)

CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS

LABOR CATEGORY	1985 HOURS	MANPOWER	COST	1986 HOURS	MANPOWER	COST	1987 HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.	0.	0.00	0.	245.	1.01	3572.
PREVENTIVE MAINT	0.	0.00	0.	0.	0.00	0.	18.	0.08	8900.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.	0.	0.00	0.	263.	1.09	12471.
BASE LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	34.	0.02	589.
DEPOT LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	2.	0.00	36.
TOTAL SYSTEM MAINT	0.		0.	0.		0.	299.		13096.

LABOR CATEGORY	1988 HOURS	MANPOWER	COST	1989 HOURS	MANPOWER	COST	1990 HOURS	MANPOWER	COST
CORRECTIVE MAINT	1728.	7.12	25191.	4411.	18.18	64324.	8285.	34.14	120811.
PREVENTIVE MAINT	147.	0.60	19405.	385.	1.59	31515.	734.	3.02	45231.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	1874.	7.72	44595.	4797.	19.77	95839.	9019.	37.17	166041.
BASE LEVEL REPAIR	270.	0.15	4709.	710.	0.40	12361.	1352.	0.76	23544.
DEPOT LEVEL REPAIR	14.	0.01	291.	37.	0.02	763.	70.	0.04	1454.
TOTAL SYSTEM MAINT	2159.		49595.	5543.		108963.	10441.		191039.

LABOR CATEGORY	1991 HOURS	MANPOWER	COST	1992 HOURS	MANPOWER	COST	1993 HOURS	MANPOWER	COST
CORRECTIVE MAINT	13343.	54.99	194564.	19582.	80.69	285527.	26801.	110.45	390799.
PREVENTIVE MAINT	1193.	4.92	60552.	1762.	7.26	77470.	2422.	9.98	95743.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	14536.	59.90	255116.	21343.	87.95	363005.	29224.	120.43	486542.
BASE LEVEL REPAIR	2196.	1.24	38259.	3244.	1.83	56506.	4460.	2.52	77695.
DEPOT LEVEL REPAIR	115.	0.06	2363.	169.	0.10	3490.	233.	0.13	4799.
TOTAL SYSTEM MAINT	16847.		295738.	24756.		423001.	33916.		569036.

LABOR CATEGORY	1994 HOURS	MANPOWER	COST	1995 HOURS	MANPOWER	COST	1996 HOURS	MANPOWER	COST
CORRECTIVE MAINT	35001.	144.23	510358.	44179.	182.06	644186.	54335.	223.91	792266.
PREVENTIVE MAINT	3175.	13.08	115345.	4019.	16.56	136285.	4955.	20.42	158563.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	38176.	157.32	625703.	48198.	198.62	780471.	59289.	244.32	950829.
BASE LEVEL REPAIR	5845.	3.31	101828.	7400.	4.19	128903.	9123.	5.16	158922.
DEPOT LEVEL REPAIR	305.	0.17	6289.	386.	0.22	7961.	476.	0.27	9815.
TOTAL SYSTEM MAINT	44326.		733820.	55963.		917336.	68888.		1119566.

LABOR CATEGORY	1997 HOURS	MANPOWER	COST	1998 HOURS	MANPOWER	COST	1999 HOURS	MANPOWER	COST
CORRECTIVE MAINT	65467.	269.78	954505.	77379.	318.87	1128288.	90072.	371.18	1313366.
PREVENTIVE MAINT	5982.	24.65	182179.	7083.	29.19	206064.	8258.	34.03	232621.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	71447.	294.43	1136764.	84462.	348.06	1335152.	98330.	405.21	1545987.
BASE LEVEL REPAIR	11015.	6.23	191884.	13042.	7.38	227200.	15205.	8.60	264870.
DEPOT LEVEL REPAIR	575.	0.32	11851.	680.	0.38	14032.	793.	0.45	16359.
TOTAL SYSTEM MAINT	83038.		1340499.	98185.		1576384.	114328.		1827216.

LABOR CATEGORY	2000 HOURS	MANPOWER	COST	2001 HOURS	MANPOWER	COST	2002 HOURS	MANPOWER	COST
CORRECTIVE MAINT	103545.	426.70	1509815.	117797.	485.43	1717629.	132828.	547.37	1936862.
PREVENTIVE MAINT	9505.	39.17	259447.	[illegible]327.	44.61	287344.	12221.	50.36	316311.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	113050.	465.87	1769262.	128624.	530.04	2004973.	145049.	597.73	2253113.
BASE LEVEL REPAIR	17502.	9.90	304395.	19935.	11.28	347274.	22503.	12.73	392008.
DEPOT LEVEL REPAIR	913.	0.52	18831.	1040.	0.59	21448.	1174.	0.66	24211.
TOTAL SYSTEM MAINT	131466.		2092988.	149598.		2373695.	168726.		2669332.

LABOR CATEGORY	2003 HOURS	MANPOWER	COST	2004 HOURS	MANPOWER	COST	2005 HOURS	MANPOWER	COST
CORRECTIVE MAINT	148638.	612.52	2167330.	165226.	680.88	2409208.	182593.	752.44	2662433.
PREVENTIVE MAINT	13689.	56.41	346348.	15231.	62.76	377456.	16845.	69.42	409634.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	162327.	668.93	2513678.	180457.	743.64	2786664.	199438.	821.86	3072067.
BASE LEVEL REPAIR	25206.	14.26	439096.	28044.	15.86	488538.	31018.	17.54	540335.
DEPOT LEVEL REPAIR	1315.	0.74	27119.	1463.	0.83	30173.	1618.	0.92	33372.
TOTAL SYSTEM MAINT	188848.		2979893.	209964.		3305375.	232074.		3645774.

LABOR CATEGORY	2006 HOURS	MANPOWER	COST	2007 HOURS	MANPOWER	COST	2008 HOURS	MANPOWER	COST
CORRECTIVE MAINT	200737.	827.21	2927001.	218882.	901.98	3191568.	237026.	976.76	3456136.
PREVENTIVE MAINT	18534.	76.37	442582.	20222.	83.33	476130.	21910.	90.29	509378.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	219271.	903.59	3369583.	239103.	985.32	3667698.	258936.	1067.04	3965514.
BASE LEVEL REPAIR	34125.	19.30	594486.	37235.	21.06	648638.	40343.	22.82	702789.
DEPOT LEVEL REPAIR	1780.	1.01	36716.	1942.	1.10	40061.	2104.	1.19	43405.
TOTAL SYSTEM MAINT	255177.		4001035.	278280.		4356396.	301383.		4711708.

LABOR CATEGORY	2009 HOURS	MANPOWER	COST
CORRECTIVE MAINT	255170.	1051.53	3720703.
PREVENTIVE MAINT	23598.	97.24	542626.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	278769.	1148.77	4263330.
BASE LEVEL REPAIR	43[illegible]52.	24.58	75[illegible]940.
DEPOT LEVEL REPAIR	2266.	1.28	[illegible]750.
TOTAL SYSTEM MAINT	324487.		5067019.

SYSTEM: BASIC-PRAZ (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

NONRECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	1874982.	32218.	87537.
SHIPPING	0.	0.	1273.	7641.	7641.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	97920.	0.	0.
TRAINING	0.	0.	5100.	7250.	8700.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	1979275.	47109.	103878.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	42053.	68339.	31717.	31771.	7519.
SHIPPING	7641.	7641.	7641.	6367.	6367.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	7250.	7250.	8700.	5800.	5800.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	56944.	83230.	48058.	43938.	19686.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	78780.	12293.	28236.	54241.	16348.
SHIPPING	6367.	6367.	6367.	5094.	5094.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	7250.	5800.	[illegible]450.	4350.	5800.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	92397.	24460.	44053.	63685.	27242.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	11630.	19729.	21280.	57434.	25535.
SHIPPING	5094.	5094.	5094.	5094.	5094.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	4350.	5800.	4350.	5800.	4350.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	21074.	30623.	30732.	68328.	34979.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	6398.	3664.	0.	0.	0.	2511712.
SHIPPING	5094.	5094.	0.	0.	0.	117155.
INVENTORY MGT	0.	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.	97920.
TRAINING	5800.	4350.	0.	0.	0.	123300.
DATA MANAGEMENT	0.	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.	0.
ANNUAL TOTAL	17292.	13108.	0.	0.	0.	2850088.

SYSTEM: BASIC-PKAZ (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

RECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	173500.	276304.	287409.
ON-SITE MAINT	0.	0.	12886.	35028.	54636.
OFF-SITE MAINT	0.	0.	931.	6515.	12100
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	1.	10.	18.
TRAINING	0.	0.	510.	1235.	2103.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	0.	0.	309.	2161.	4014.
ANNUAL TOTAL	0.	0.	188137.	321253.	362282.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	318605.	324036.	350102.	358970.	363581.
ON-SITE MAINT	78084.	99445.	120749.	138470.	156169.
OFF-SITE MAINT	17684.	23269.	28853.	33507.	38161.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	27.	35.	44.	51.	58.
TRAINING	2830.	3555.	4425.	5005.	5585.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	5866.	7719.	9571.	11115.	12658.
ANNUAL TOTAL	423096.	458058.	513744.	547118.	576212.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	388677.	397578.	401828.	406407.	432556.
ON-SITE MAINT	173849.	191514.	209165.	223277.	237383.
OFF-SITE MAINT	42815.	47469.	52122.	55845.	59568.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	65.	72.	79.	84.	90.
TRAINING	6310.	6890.	7835.	8270.	8850.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	14202.	15746.	17289.	18524.	19759.
ANNUAL TOTAL	625918.	659268.	688318.	712408.	758207.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	437943.	442298.	465786.	472101.	475531.
ON-SITE MAINT	251483.	265577.	279664.	293751.	307831.
OFF-SITE MAINT	63271.	67014.	70737.	74460.	78183.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	95.	101.	107.	112.	118.
TRAINING	9285.	9865.	10300.	10880.	11315.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
SITE OPERATION	20994.	22229.	23464.	24699.	25934.
ANNUAL TOTAL	783092.	807085.	850061.	876004.	898912.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	481980.	505331.	505331.	505331.	505331.	9276516.
ON-SITE MAINT	321907.	335779.	335979.	335979.	335979.	4776736.
OFF-SITE MAINT	81907.	85630.	85630.	85630.	85630.	1196952.
INVENTORY MGT	0.	0.	0.	0.	0.	0.
SUPPORT EQUIP	123.	129.	129.	129.	129.	1805.
TRAINING	11895.	12330.	12330.	12330.	12330.	176265.
DATA MANAGEMENT	0.	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.	0.
SITE OPERATION	27169.	28404.	28404.	28404.	28404.	397040.
ANNUAL TOTAL	924981.	967803.	967803.	967803.	967803.	15845364.

SYSTEM: BASIC-BNA? (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR10.00
SYSTEM COST: $ 151744.00

TOTAL LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	156296.	937778.	937778.	937778.	937778.
INSTALLATION	0.	0.	25100.	150600.	150600.
NONRECURRING	0.	0.	1979275.	47109.	103078.
RECURRING	0.	0.	188137.	[illegible]	[illegible]
TOTAL LOGISTIC	0.	0.	2167413.	360362.	466159.
TOTAL PROGRAM	156296.	937778.	3130291.	1456739.	1554537.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	937778.	781482.	781482.	781482.	781482.
INSTALLATION	150600.	150600.	150600.	125500.	125500.
NONRECURRING	56944.	83230.	48058.	43938.	19686.
RECURRING	423096.	458058.	513744.	547118.	576212.
TOTAL LOGISTIC	480040.	541288.	561801.	591056.	595898.
TOTAL PROGRAM	1568418.	1473370.	1493083.	1498037.	1502880.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	781482.	625185.	625185.	625185.	625185.
INSTALLATION	125500.	125500.	125500.	100400.	100400.
NONRECURRING	92397.	24460.	44053.	[illegible]	27242.
RECURRING	625918.	659268.	688318.	712408.	758207.
TOTAL LOGISTIC	718315.	683728.	732371.	776093.	785449.
TOTAL PROGRAM	1625296.	1434413.	1483057.	1501678.	1511034.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	625185.	625185.	625185.	625185.	625185.
INSTALLATION	100400.	100400.	100400.	100400.	100400.
NONRECURRING	21074.	30623.	30732.	68328.	34979.
RECURRING	783092.	807085.	850061.	876004.	898912.
TOTAL LOGISTIC	804166.	837708.	880792.	944331.	933891.
TOTAL PROGRAM	1529751.	1563293.	1606378.	1669917.	1659476.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
ACQUISITION	0.	0.	0.	0.	0.	14379259.
INSTALLATION	100400.	100400.	0.	0.	0.	2309200.
NONRECURRING	17292.	13108.	0.	0.	0.	2850088.
RECURRING	924981.	967803.	967803.	967803.	967803.	15845366.
TOTAL LOGISTIC	942273.	980910.	967803.	967803.	967803.	18695450.
TOTAL PROGRAM	1042673.	1081310.	967803.	967803.	967803.	35383916.

CUMULATIVE LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	156296.	1094074.	2031852.	2969630.	3907408.
INSTALLATION	0.	0.	25100.	175700.	326300.
NONRECURRING	0.	0.	[illegible]	2026384.	2130262.
RECURRING	0.	0.	[illegible]	509390.	871672.
TOTAL LOGISTIC	0.	0.	2167413.	2535774.	3001934.
TOTAL PROGRAM	156296.	1094074.	4224365.	5681104.	7235642.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	4845186.	5626668.	6408149.	7189631.	7971112.
INSTALLATION	476900.	627500.	778100.	903600.	1029100.
NONRECURRING	2187205.	2270435.	2318492.	2362430.	2382117.
RECURRING	1294768.	1752827.	2266570.	2813608.	3389900.
TOTAL LOGISTIC	3481973.	4023261.	4585063.	5176118.	5772016.
TOTAL PROGRAM	8804059.	10277429.	11771312.	13269350.	14772230.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	8752594.	9377779.	10002964.	10628149.	11253334.
INSTALLATION	1154600.	1280100.	1405600.	1506000.	1606400.
NONRECURRING	2474514.	2498974.	2543027.	2606712.	2633954.
RECURRING	4015817.	4675085.	5363403.	6075811.	6834019.
TOTAL LOGISTIC	6490331.	7174058.	7906430.	[illegible]	9467972.
TOTAL PROGRAM	16397527.	17831940.	19314998.	2081667.	22327712.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	11878519.	12503704.	13128889.	13754074.	14379259.
INSTALLATION	1706800.	1807200.	1907600.	2008000.	2108400.
NONRECURRING	2655028.	2685650.	2716382.	2784710.	2819689.
RECURRING	7617110.	8424196.	9274257.	10150261.	11049173.
TOTAL LOGISTIC	10272138.	11109846.	11990638.	12934969.	13868860.
TOTAL PROGRAM	23857464.	25420758.	27027136.	28697054.	30356532.

COST CATEGORY	2005	2006	2007	2008	2009
ACQUISITION	[illegible]	14379259.	14379259.	14379259	14379259.
INSTALLATION	2208800.	2309200.	2309200.	2309200.	2309200.
NONRECURRING	2836980.	2850088.	2850088.	2850088.	2850088.
RECURRING	11974154.	12941957.	13909760.	14877563.	15845366.
TOTAL LOGISTIC	14811133.	15792043.	16759846.	17727648.	18695450.
TOTAL PROGRAM	31399204.	32480514.	33448316.	34416120.	35383924.

SYSTEM TYPE: BASIC II (180)

ANNUAL MAINTENANCE HOURS AND LABOR COSTS

	1985			1986			1987		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.	0.		0.	0.		0.

	1988			1989			1990		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	5364.	22.10	78210.	10567.	43.54	154074.	15743.	64.87	229552.
PREVENTIVE MAINT	147.	0.60	10773.	294.	1.21	12913.	440.	1.81	15054.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	5511.	22.71	88982.	10860.	44.75	166987.	16183.	66.69	244606.
BASE LEVEL REPAIR	1033.	0.58	17992.	2066.	1.17	35984.	3098.	1.75	53975.
DEPOT LEVEL REPAIR	54.	0.03	1113.	108.	0.06	2225.	162.	0.09	3338.
TOTAL SYSTEM MAINT	6597.		108087.	13034.		205196.	19444.		301919.

	1991			1992			1993		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	20261.	83.49	295429.	25416.	104.74	370594.	25416.	104.74	370594.
PREVENTIVE MAINT	569.	2.34	16927.	716.	2.95	19067.	716.	2.95	19067.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	20830.	85.84	312356.	26131.	107.68	389661.	26131.	107.68	389661.
BASE LEVEL REPAIR	4002.	2.26	69718.	5035.	2.85	87710.	5035.	2.85	87710.
DEPOT LEVEL REPAIR	209.	0.12	4312.	263.	0.15	5424.	263.	0.15	5424.
TOTAL SYSTEM MAINT	25041.		386385.	31429.		482795.	31429.		482795.

	1994			1995			1996		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	25416.	104.74	370594.	25416.	104.74	370594.	25416.	104.74	370594.
PREVENTIVE MAINT	716.	2.95	19067.	716	2.95	19067.	716.	2.95	19067.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	26131.	107.68	389661.	26131.	107.68	389661.	26131.	107.68	389661.
BASE LEVEL REPAIR	5035.	2.85	87710.	5035.	2.85	87710.	5035.	2.85	87710.
DEPOT LEVEL REPAIR	263.	0.15	5424.	263.	0.15	5424.	263.	0.15	5424.
TOTAL SYSTEM MAINT	31429.		482795.	31429.		482795.	31429.		482795.

	1997			1998			1999		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	25416.	104.74	370594.	35708.	147.15	520663.	45984.	189.49	670504.
PREVENTIVE MAINT	716.	2.95	19067.	1009.	4.16	23348.	1303.	5.37	27629.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	26131.	107.68	389661.	36717.	151.31	544011.	47287.	194.86	698133.
BASE LEVEL REPAIR	5035.	2.85	87710.	7101.	4.02	173693.	9166.	5.18	159677.
DEPOT LEVEL REPAIR	263.	0.15	5424.	371.	21	7650.	479	0.27	9875.
TOTAL SYSTEM MAINT	31429.		482795.	44188.		675354.	56932.		867686.

	2000			200[illegible]			2002		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	[illegible]	HOURS	MANPOWER	COST
CORRECTIVE MAINT	56250.	231.80	820191.	66508.	[illegible]74.07	[illegible]9766.	76760.	316.32	1119253.
PREVENTIVE MAINT	1596.	6.58	31910.	1890.	[illegible]	3[illegible]191.	2184.	9.00	40472.
CALL-BACK MAINT	0.	0.00	0.	0.	[illegible]	0.	0.	0.00	0.
TOTAL SITE MAINT	57846.	238.38	852101.	68398.	281.	1005957.	78943.	325.32	1159725.
BASE LEVEL REPAIR	11232.	6.35	195661.	13297.	7.52	231644.	15363.	8.69	267628.
DEPOT LEVEL REPAIR	587.	0.33	12101.	694.	0.39	14326.	802.	0.45	16552.
TOTAL SYSTEM MAINT	69665.		1059863.	82390.		1251927.	95109.		1443904.

	2003			2004			2005		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	87647.	361.18	1278006.	98530.	406.03	1436694.	110049.	453.50	1604659.
PREVENTIVE MAINT	2496.	10.28	45021.	2808.	11.57	49570.	3138.	12.93	54386.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	90143.	371.47	1323027.	101338.	417.60	1486264.	113187.	466.43	1659044.
BASE LEVEL REPAIR	17558.	9.93	305860.	19753.	11.17	344093.	22076.	12.49	384574.
DEPOT LEVEL REPAIR	917.	0.52	18916.	1032.	0.58	21281.	1153.	0.65	23784.
TOTAL SYSTEM MAINT	108618.		1647803.	122122.		1851637.	136417.		2067403.

	2006			2007			2008		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	120925.	498.32	17632[illegible].	120925.	498.32	1763244.	120925.	498.32	1763244.
PREVENTIVE MAINT	3450.	14.22	58934.	3450.	14.22	58934.	3450.	14.22	58934.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	124375.	512.54	1822179.	124375.	512.54	1822179.	124375.	512.54	1822179.
BASE LEVEL REPAIR	24271.	13.73	422807.	24271.	13.73	422807.	24271.	13.73	422807.
DEPOT LEVEL REPAIR	1268.	0.72	26149.	1268.	0.72	26149.	1268.	0.72	26149.
TOTAL SYSTEM MAINT	149914.		2271134.	149914.		2271134.	149914.		2271134.

	2009			TOTALS		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	120925.	498.32	1763244.	1265566.	5215.25	18453538.
PREVENTIVE MAINT	3450.	14.22	58934.	35966.	148.21	714333.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	124375.	512.54	1822179.	1301532.	5363.46	19167872.
BASE LEVEL REPAIR	24271.	13.73	[illegible]2807.	253039.	143.12	4407985.
DEPOT LEVEL REPAIR	1268.	0.72	26149.	13215.	7.47	272614.
TOTAL SYSTEM MAINT	149914.		2271134.	1567786.		23848470.

SYSTEM TYPE: BASIC II (180)

CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS

1985

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1986

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1987

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1988

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	5364.	22.10	78210.
PREVENTIVE MAINT	147.	0.60	10773.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	5511.	22.71	88982.
BASE LEVEL REPAIR	1033.	0.58	17992.
DEPOT LEVEL REPAIR	54.	0.03	1113.
TOTAL SYSTEM MAINT	6597.		108087.

1989

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	15930.	65.65	232294.
PREVENTIVE MAINT	440.	1.81	23686.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16371.	67.46	255969.
BASE LEVEL REPAIR	3098.	1.75	53975.
DEPOT LEVEL REPAIR	162.	0.09	3338.
TOTAL SYSTEM MAINT	19631.		313283.

1990

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	31673.	130.52	461836.
PREVENTIVE MAINT	881.	3.63	38737.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	32554.	134.15	500575.
BASE LEVEL REPAIR	6197.	3. 1	107951.
DEPOT LEVEL REPAIR	324.	0.18	6676.
TOTAL SYSTEM MAINT	39075.		615202.

1991

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	51934.	214.01	757265.
PREVENTIVE MAINT	1450.	5.97	55666.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	53384.	219.99	812931.
BASE LEVEL REPAIR	10199.	5.77	177669.
DEPOT LEVEL REPAIR	533.	0.30	10988.
TOTAL SYSTEM MAINT	64116.		1001588.

1992

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	77350.	318.75	1127859.
PREVENTIVE MAINT	2165.	8.92	74733.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	79515.	327.67	1202592.
BASE LEVEL REPAIR	15234.	8.62	265379.
DEPOT LEVEL REPAIR	796.	0.45	16412.
TOTAL SYSTEM MAINT	95545.		1484383.

1993

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	102766.	423.49	1498452.
PREVENTIVE MAINT	2881.	11.87	93800.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	105647.	435.36	1592252.
BASE LEVEL REPAIR	20269.	11.46	353089.
DEPOT LEVEL REPAIR	1059.	0.60	21837.
TOTAL SYSTEM MAINT	126974.		1967178.

1994

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	128181.	528.22	1869046.
PREVENTIVE MAINT	3597.	14.82	112867.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	131778.	543.04	1981913.
BASE LEVEL REPAIR	25304.	14.31	440798.
DEPOT LEVEL REPAIR	1322.	0.75	27261.
TOTAL SYSTEM MAINT	158403.		2449973.

1995

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	153597.	632.96	2239639.
PREVENTIVE MAINT	4312.	17.77	131934.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	157909.	650.73	2371574.
BASE LEVEL REPAIR	30339.	17.16	528508.
DEPOT LEVEL REPAIR	1585.	0.90	32686.
TOTAL SYSTEM MAINT	189833.		2932768.

1996

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	179013.	737.69	2610233.
PREVENTIVE MAINT	5028.	20.72	151001.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	184041.	758.[illegible]	2761234.
BASE LEVEL REPAIR	35374.	20.[illegible]	616218.
DEPOT LEVEL REPAIR	1847.	1.0	38110.
TOTAL SYSTEM MAINT	221262.		3415563.

1997

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	204429.	842.43	2980826.
PREVENTIVE MAINT	5744.	23.67	170068.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	210172.	866.09	3150895.
BASE LEVEL REPAIR	40409.	22.86	703928.
DEPOT LEVEL REPAIR	2110.	1.19	43535.
TOTAL SYSTEM MAINT	252691.		3898358.

1998

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	240136.	989.57	3501489.
PREVENTIVE MAINT	6753.	27.83	193416.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	246889.	1017.40	3694906.
BASE LEVEL REPAIR	47509.	26.87	827622.
DEPOT LEVEL REPAIR	2481.	1.40	51185.
TOTAL SYSTEM MAINT	296880.		4573712.

1999

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	286120.	1179.07	4171993.
PREVENTIVE MAINT	8056.	33.20	221045.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	294176.	1212.26	4393039.
BASE LEVEL REPAIR	56676.	32.06	987299.
DEPOT LEVEL REPAIR	2960.	1.67	61060.
TOTAL SYSTEM MAINT	353812.		5441398.

2000

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	342370.	1410.87	4992185.
PREVENTIVE MAINT	9652.	39.78	252956.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	352022.	1450.64	5245141.
BASE LEVEL REPAIR	67907.	38.41	1182959.
DEPOT LEVEL REPAIR	3547.	2.01	73161.
TOTAL SYSTEM MAINT	423476.		6501260.

2001

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	408878.	1684.94	5961950.
PREVENTIVE MAINT	11542.	47.56	289147.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	420420.	1732.50	6251098.
BASE LEVEL REPAIR	81205.	45.93	1414603.
DEPOT LEVEL REPAIR	4241.	2.40	87487.
TOTAL SYSTEM MAINT	505866.		7753187.

2002

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	485638.	2001.25	7081203.
PREVENTIVE MAINT	13726.	56.56	329619.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	499363.	2057.82	7410823.
BASE LEVEL REPAIR	96568.	54.62	1682231.
DEPOT LEVEL REPAIR	5043.	2.85	104038.
TOTAL SYSTEM MAINT	600975.		9197091.

2003

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	573285.	2362.44	8359209.
PREVENTIVE MAINT	16221.	66.85	374640.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	589506.	2429.28	8733849.
BASE LEVEL REPAIR	114126.	64.55	1988091.
DEPOT LEVEL REPAIR	5960.	3.37	122954.
TOTAL SYSTEM MAINT	709592.		10844894.

2004

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	671915.	2768.47	9795903.
PREVENTIVE MAINT	19029.	78.42	424210.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	690844.	2846.88	10220113.
BASE LEVEL REPAIR	133878.	75.72	2332184.
DEPOT LEVEL REPAIR	6992.	3.95	144235.
TOTAL SYSTEM MAINT	831714.		12696531.

2005

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	781865.	3221.97	11400562.
PREVENTIVE MAINT	22167.	91.35	478596.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	804031.	3313.32	11879157.
BASE LEVEL REPAIR	155955.	88.21	2716758.
DEPOT LEVEL REPAIR	8145.	4.61	168019.
TOTAL SYSTEM MAINT	968131.		14763934.

2006

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	902790.	3720.29	3153806.
PREVENTIVE MAINT	25617.	105.56	537530.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	928407.	3825.85	13701336.
BASE LEVEL REPAIR	180226.	101.94	3139565.
DEPOT LEVEL REPAIR	9413.	5.32	194168.
TOTAL SYSTEM MAINT	1118045.		17035068.

2007

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1023715.	4218.61	14927050.
PREVENTIVE MAINT	29066.	119.78	596464.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1052782.	4338.39	15523515.
BASE LEVEL REPAIR	204197.	115.67	3562372.
DEPOT LEVEL REPAIR	10680.	6.04	220316.
TOTAL SYSTEM MAINT	1267959.		19304202.

2008

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1144641.	4716.93	16690294.
PREVENTIVE MAINT	32516.	134.00	655399.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1177157.	4850.92	17345694.
BASE LEVEL REPAIR	228768.	129.39	3985178.
DEPOT LEVEL REPAIR	11948.	6.76	246465.
TOTAL SYSTEM MAINT	1417873.		21577336.

2009

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	1265566.	5215.25	18453538.
PREVENTIVE MAINT	35966.	148.21	714333.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	1301532.	5363.46	19167872.
BASE LEVEL REPAIR	253039.	143.12	4407985.
DEPOT LEVEL REPAIR	13215.	7.47	272614.
TOTAL SYSTEM MAINT	1567784.		23848470.

SYSTEM: BASIC II (100)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

NONRECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	0.	7203225.	343638.
SHIPPING	0.	0.	0.	14249.	14249.
INVENTORY MGT	0.	0.	0.	37200.	0.
SUPPORT EQUIP	0.	0.	0.	97920.	0.
TRAINING	0.	0.	0.	35550.	34100.
DATA MANAGEMENT	0.	0.	0.	7860000.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	0.	15248145.	397007.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	64413.	299903.	96643.	0.	0.
SHIPPING	14249.	12468.	14249.	0.	0.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	31900.	29750.	31900.	0.	0.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	110565.	342121.	142792.	0.	0.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	0.	0.	0.	347017.	379768.
SHIPPING	0.	0.	0.	28499.	28499.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	0.	0.	0.	68200.	64550.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	0.	443716.	472817.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	360375.	307841.	377189.	392728.	199872.
SHIPPING	28499.	28499.	28499.	30280.	30280.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	66000.	64550.	66000.	68900.	71100.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	454874.	400890.	471688.	491908.	301252.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	831304.	593995.	0.	0.	0.	11802934.
SHIPPING	32061.	30280.	0.	0.	0.	334859.
INVENTORY MGT	0.	0.	0.	0.	0.	37200.
SUPPORT EQUIP	0.	0.	0.	0.	0.	97920.
TRAINING	73250.	68900.	0.	0.	0.	774650.
DATA MANAGEMENT	0.	0.	0.	0.	0.	7860000.
FACILITIES	0.	0.	0.	0.	0.	0.
ANNUAL TOTAL	936615.	693175.	0.	0.	0.	20907564.

SYSTEM: BASIC II (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

RECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	0.	795870.	845133.
ON-SITE MAINT	0.	0.	0.	98869.	186760.
OFF-SITE MAINT	0.	0.	0.	30275.	60549.
INVENTORY MGT	0.	0.	0.	4650.	4650.
SUPPORT EQUIP	0.	0.	0.	124.	248.
TRAINING	0.	0.	0.	3555.	6965.
DATA MANAGEMENT	0.	0.	0.	93600.	93600.
FACILITIES	0.	0.	0.	78000.	78000.
SITE OPERATION	0.	0.	0.	22360.	44720.
ANNUAL TOTAL	0.	0.	0.	1127310.	1320625.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	899379.	941488.	998337.	998337.	998337.
ON-SITE MAINT	274265.	350665.	437056.	437056.	437056.
OFF-SITE MAINT	90824.	117315.	147589.	147589.	147589.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	372.	480.	604.	604.	604.
TRAINING	10155.	13130.	16320.	16320.	16320.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	67080.	86645.	109005.	109005.	109005.
ANNUAL TOTAL	1518325.	1685973.	1885962.	1685962.	1885962.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	998337.	998337.	998337.	1126157.	1486746.
ON-SITE MAINT	437856.	437856.	437856.	611980.	785075.
OFF-SITE MAINT	147589.	147589.	147589.	208139.	260688.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	604.	604.	604.	852.	1100.
TRAINING	16320.	16320.	16320.	23140.	29595.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	109005.	109005.	109005.	153725.	198445.
ANNUAL TOTAL	1885962.	1885962.	1885962.	2300239.	2946700.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	1671763.	1790240.	1968637.	2350994.	2452734.
ON-SITE MAINT	959615.	1133244.	1306704.	1491075.	1675340.
OFF-SITE MAINT	329238.	389787.	450337.	514671.	579005.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	1346.	1596.	1844.	2108.	2371.
TRAINING	36195.	42650.	49250.	56140.	63250.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	243165.	287885.	332405.	380120.	427635.
ANNUAL TOTAL	3417572.	3821652.	4285708.	4971378.	5376585.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	2650371.	2790747.	2790747.	2790747.	2790747.	[illegible]132532.
ON-SITE MAINT	1870365.	2054508.	2054508.	2054508.	2054508.	21599036.
OFF-SITE MAINT	647123.	711457.	711457.	711457.	711457.	7417313.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.	102300.
SUPPORT EQUIP	2450.	2914.	2914.	2914.	2914.	30377.
TRAINING	70575.	77465.	77465.	77465.	77465.	812330.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.	2059200.
FACILITIES	78000.	78000.	78000.	78000.	78000.	1716000.
SITE OPERATION	477945.	525460.	525460.	525460.	525460.	5478200.
ANNUAL TOTAL	5875279.	6338800.	6338800.	6338800.	6338800.	75338336.

SYSTEM: BASIC II (100)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00
SYSTEM COST: $ 535008.00

TOTAL LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	0.	4415058.	4415058.	4415058.	[illegible]
INSTALLATION	0.	0.	0.	2083200.	2083200.
NONRECURRING	0.	0.	0.	15240145.	397007.
RECURRING	0.	0.	0.	1127310.	1320625.
TOTAL LOGISTIC	0.	0.	0.	16375455.	1717633.
TOTAL PROGRAM	0.	4415058.	4415058.	22873714.	7664009.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	4415058.	0.	0.	0.	0.
INSTALLATION	2083200.	1822800.	2083200.	0.	0.
NONRECURRING	110565.	342121.	142792.	0.	0.
RECURRING	1518325.	1685973.	1885962.	1885962.	1885962.
TOTAL LOGISTIC	1628891.	2028095.	2028755.	1885962.	1885962.
TOTAL PROGRAM	8127149.	3850895.	4111[illegible]55.	1885962.	1885962.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	0.	8830116.	8830116.	8830116.	8830116.
INSTALLATION	0.	0.	0.	4166400.	4166400.
NONRECURRING	0.	0.	0.	443716.	472817.
RECURRING	1885962.	1885962.	1885962.	2300239.	2946700.
TOTAL LOGISTIC	1885962.	1885962.	1885962.	2743955.	3419516.
TOTAL PROGRAM	1885962.	10716078.	10716078.	15740471.	16416032.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	8830116.	9381998.	9381998.	9933881.	9381998.
INSTALLATION	4166400.	4166400.	4166400.	4426800.	4426800.
NONRECURRING	454874.	400890.	471688.	491908.	301252.
RECURRING	3417575.	3821652.	4285708.	4971378.	5376585.
TOTAL LOGISTIC	3872449.	4222542.	4757395.	5463286.	5677837.
TOTAL PROGRAM	16868966.	17770940.	18305794.	19023968.	19486636.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
ACQUISITION	0.	0.	0.	0.	0.	103753864.
INSTALLATION	4687200.	4426800.	0.	0.	0.	48955200.
NONRECURRING	936615.	693175.	0.	0.	0.	20907562.
RECURRING	5895279.	6338800.	6338800.	6338800.	6338800.	75338320.
TOTAL LOGISTIC	6831894.	7031975.	6338800.	6338800.	6338800.	96245880.
TOTAL PROGRAM	11519094.	11[illegible]58775.	6338800.	6338800.	6338800.	248954960.

CUMULATIVE LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	0.	4415058.	8830116.	13245174.	17108350.
INSTALLATION	0.	0.	0.	2083200.	4166400.
NONRECURRING	0.	0.	0.	15248145.	15645152.
RECURRING	0.	0.	0.	1127310.	2447936.
TOTAL LOGISTIC	0.	0.	0.	16375455.	18093088.
TOTAL PROGRAM	0.	4415058.	8830116.	31703830.	39367836.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	21523408.	21523408.	21523408.	21523408.	21523408.
INSTALLATION	6249600.	8072400.	10155600.	10155600.	10155600.
NONRECURRING	15755717.	16097838.	16240630.	16240630.	16240630.
RECURRING	3966261.	5652235.	7538197.	9424159.	[illegible]
TOTAL LOGISTIC	19721978.	21750072.	23778826.	25664788.	27550750.
TOTAL PROGRAM	47494988.	51345084.	55457840.	57343804.	59229768.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	21523408.	30353524.	39183640.	48013756.	56843872.
INSTALLATION	10155600.	10155600.	10155600.	14322000.	18488400.
NONRECURRING	16240630.	16240630.	162406[illegible].	16684346.	17157162.
RECURRING	13196083.	15082045.	16968008.	19268248.	22214748.
TOTAL LOGISTIC	29436712.	31322674.	33208636.	35952592.	373[illegible]2108.
TOTAL PROGRAM	61115732.	71831808.	82547888.	98288360.	114704400.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	65673988.	75055984.	84437984.	94371864.	103753864.
INSTALLATION	22654800.	26821200.	30987600.	35414400.	39841200.
NONRECURRING	17612036.	18012926.	18484614.	18976522.	19277774.
RECURRING	25632522.	29454174.	33739880.	38711256.	44087840.
TOTAL LOGISTIC	43244556.	47467096.	52224492.	57687776.	63365612.
TOTAL PROGRAM	131573368.	149344304.	167650096.	187474064.	[illegible]

COST CATEGORY	2005	2006	2007	2008	2009
ACQUISITION	103753864.	103753864.	103753864.	103753864.	103753864.
INSTALLATION	44528400.	48955200.	48955200.	48955200.	48955200.
NONRECURRING	20214388.	20907562.	20907562.	20907562.	20907562.
RECURRING	49983120.	56321920.	62660720.	68999520.	75338320.
TOTAL LOGISTIC	70197504.	77229400.	83568280.	89907080.	96245880.
TOTAL PROGRAM	218479792.	229938560.	236277360.	242616160.	248954960.

SYSTEM TYPE: EXPANDED (180)

ANNUAL MAINTENANCE HOURS AND LABOR COSTS

1985

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1986

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1987

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.

1988

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3681.	15.17	53680.
PREVENTIVE MAINT	92.	0.38	9970.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	3773.	15.55	63650.
BASE LEVEL REPAIR	650.	0.37	11316.
DEPOT LEVEL REPAIR	34.	0.02	700.
TOTAL SYSTEM MAINT	4457.		75665.

1989

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	6523.	26.88	95111.
PREVENTIVE MAINT	165.	0.68	11040.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	6688.	27.56	106152.
BASE LEVEL REPAIR	1169.	0.66	20368.
DEPOT LEVEL REPAIR	61.	0.03	1260.
TOTAL SYSTEM MAINT	7918.		127780.

1990

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	10053.	41.43	146586.
PREVENTIVE MAINT	257.	1.06	12378.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	10310.	42.49	158964.
BASE LEVEL REPAIR	1819.	1.03	31684.
DEPOT LEVEL REPAIR	95.	0.05	1960.
TOTAL SYSTEM MAINT	12224.		192608.

1991

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	12868.	53.03	187630.
PREVENTIVE MAINT	330.	1.36	13448.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	13198.	54.39	201078.
BASE LEVEL REPAIR	2338.	1.32	40737.
DEPOT LEVEL REPAIR	122.	0.07	2520.
TOTAL SYSTEM MAINT	15659.		244334.

1992

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	16379.	67.50	238827.
PREVENTIVE MAINT	422.	1.74	14786.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16801.	69.24	253613.
BASE LEVEL REPAIR	2988.	1.69	52053.
DEPOT LEVEL REPAIR	156.	0.09	3219.
TOTAL SYSTEM MAINT	19945.		308885.

1993

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	16379.	67.50	238827.
PREVENTIVE MAINT	422.	1.74	14786.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16801.	69.24	253613.
BASE LEVEL REPAIR	2988.	1.69	52053.
DEPOT LEVEL REPAIR	156.	0.09	3219.
TOTAL SYSTEM MAINT	19945.		308885.

1994

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	16379.	67.50	238827.
PREVENTIVE MAINT	422.	1.74	14786.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16801.	69.24	253613.
BASE LEVEL REPAIR	2988.	1.69	52053.
DEPOT LEVEL REPAIR	156.	0.09	3219.
TOTAL SYSTEM MAINT	19945.		308885.

1995

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	16379.	67.50	238827.
PREVENTIVE MAINT	422.	1.74	14786.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16801.	69.24	253613.
BASE LEVEL REPAIR	2988.	1.69	52053.
DEPOT LEVEL REPAIR	156.	0.09	3219.
TOTAL SYSTEM MAINT	19945.		308885.

1996

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	16379.	67.50	238827.
PREVENTIVE MAINT	422.	1.74	14786.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	16801.	69.24	253613.
BASE LEVEL REPAIR	2988.	1.69	52053.
DEPOT LEVEL REPAIR	156.	0.09	3219.
TOTAL SYSTEM MAINT	19945.		308885.

1997

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	16379.	67.50	238827.
PREVENTIVE MAINT	422.	1.74	14786.
CALL-BACK MAINT	0	0.00	0.
TOTAL SITE MAINT	16801.	69.24	253613.
BASE LEVEL REPAIR	2988.	1.69	52053.
DEPOT LEVEL REPAIR	156.	0.09	3219.
TOTAL SYSTEM MAINT	19945.		308885.

1998

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	19184.	79.05	279722.
PREVENTIVE MAINT	495.	2.04	15856.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	19679.	81.10	295578.
BASE LEVEL REPAIR	3508.	1.98	61107.
DEPOT LEVEL REPAIR	183.	0.10	3779.
TOTAL SYSTEM MAINT	23370.		360463.

1999

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	21985.	90.60	320575.
PREVENTIVE MAINT	569.	2.34	16927.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	22554.	92.94	337501.
BASE LEVEL REPAIR	4027.	2.28	70156.
DEPOT LEVEL REPAIR	210.	0.12	4339.
TOTAL SYSTEM MAINT	26792.		411990.

2000

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	24785.	102.14	361393.
PREVENTIVE MAINT	642.	2.65	17997.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	25427.	104.78	379390.
BASE LEVEL REPAIR	4547.	2.57	79210.
DEPOT LEVEL REPAIR	237.	0.13	4899.
TOTAL SYSTEM MAINT	30212.		463499.

2001

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	27582.	113.66	402183.
PREVENTIVE MAINT	716.	2.95	19067.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	28298.	116.61	421250.
BASE LEVEL REPAIR	5067.	2.87	88263.
DEPOT LEVEL REPAIR	265.	0.15	5459.
TOTAL SYSTEM MAINT	33629.		514972.

2002

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	30378.	125.18	442948.
PREVENTIVE MAINT	789.	3.25	20137.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	31167.	128.44	463085.
BASE LEVEL REPAIR	5586.	3.16	97316.
DEPOT LEVEL REPAIR	292.	0.17	6019.
TOTAL SYSTEM MAINT	37045.		566420.

2003

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	33172.	136.70	483693.
PREVENTIVE MAINT	862.	3.55	21208.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	34035.	140.25	504900.
BASE LEVEL REPAIR	6106.	3.45	106368.
DEPOT LEVEL REPAIR	319.	0.18	6579.
TOTAL SYSTEM MAINT	40460.		617847.

2004

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	36663.	151.09	534598.
PREVENTIVE MAINT	954.	3.93	22545.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	37618.	155.02	557143.
BASE LEVEL REPAIR	6756.	3.82	117684.
DEPOT LEVEL REPAIR	353.	0.20	7279.
TOTAL SYSTEM MAINT	44726.		682106.

2005

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	40153.	165.46	585478.
PREVENTIVE MAINT	1046.	4.31	23883.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	41199.	169.78	609361.
BASE LEVEL REPAIR	7405.	4.19	129000.
DEPOT LEVEL REPAIR	387.	0.22	7978.
TOTAL SYSTEM MAINT	48991.		746339.

2006

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	43641.	179.84	636337.
PREVENTIVE MAINT	1138.	4.69	25221.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	44778.	184.53	661558.
BASE LEVEL REPAIR	8055.	4.56	140316.
DEPOT LEVEL REPAIR	421.	0.24	8678.
TOTAL SYSTEM MAINT	53254.		810552.

2007

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	43641.	179.84	636337.
PREVENTIVE MAINT	1138.	4.69	25221.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	44778.	184.53	661558.
BASE LEVEL REPAIR	8055.	4.56	140316.
DEPOT LEVEL REPAIR	421.	0.24	8678.
TOTAL SYSTEM MAINT	53254.		810552.

2008

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	43641.	179.84	636337.
PREVENTIVE MAINT	1138.	4.69	25221.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	44778	184.53	661558.
BASE LEVEL REPAIR	8055.	4.56	140316.
DEPOT LEVEL REPAIR	421.	0.24	8678.
TOTAL SYSTEM MAINT	53254.		810552.

2009

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	43641.	179.84	636337.
PREVENTIVE MAINT	1138.	4.69	25221.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	44778.	184.53	661558.
BASE LEVEL REPAIR	8055.	4.56	140316.
DEPOT LEVEL REPAIR	421.	0.24	8678.
TOTAL SYSTEM MAINT	53254.		810552.

TOTALS

LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	539865.	2224.72	7871904.
PREVENTIVE MAINT	[illegible]	[illegible]	394057.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	553866.	[illegible]	8265960.
BASE LEVEL REPAIR	99126.	56.0	1726780.
DEPOT LEVEL REPAIR	5177.	[illegible]	106799.
TOTAL SYSTEM MAINT	658169.		10099546.

SYSTEM TYPE: EXPANDED (100)

CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS

	1985			1986			1987		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
PREVENTIVE MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
BASE LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
DEPOT LEVEL REPAIR	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SYSTEM MAINT	0.		0.	0.		0.	0.		0.

	1988			1989			1990		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	3681.	15.17	53680.	10204.	42.05	148791.	20257.	83.48	295378.
PREVENTIVE MAINT	92.	0.38	9970.	257.	1.06	21010.	514.	2.12	33388.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	3773.	15.55	63650.	10461.	43.11	169801.	20771.	85.60	328765.
BASE LEVEL REPAIR	650.	0.37	11316.	1819.	1.03	31684.	3638.	2.06	63368.
DEPOT LEVEL REPAIR	34.	0.02	700.	95.	0.05	1960.	190.	0.11	3919.
TOTAL SYSTEM MAINT	4457.		75665.	12375.		203445.	24599.		396053.

	1991			1992			1993		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	33125.	136.51	483007.	49504.	204.00	721834.	65083.	271.50	960661.
PREVENTIVE MAINT	844.	3.48	46836.	1256.	5.22	61622.	1683.	6.96	76408.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	33969.	139.98	529843.	50770.	209.22	783456.	67771.	278.45	1037069.
BASE LEVEL REPAIR	5976.	3.38	104105.	8964.	5.07	156158.	11952.	6.76	208210.
DEPOT LEVEL REPAIR	312.	0.18	6439.	468.	0.26	9658.	624.	0.35	12877.
TOTAL SYSTEM MAINT	40258.		640387.	60203.		949272.	80148.		1258157.

	1994			1995			1996		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	82262.	338.99	1199487.	98641.	406.49	1430314.	115020.	473.98	1677141.
PREVENTIVE MAINT	2110.	8.70	91194.	2532.	10.44	105980.	2954.	12.17	120766.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	84373.	347.69	1290682.	101174.	416.92	1544294.	117975.	486.16	1797907.
BASE LEVEL REPAIR	14940.	8.45	260263.	17928.	10.14	312316.	20916.	11.83	364368.
DEPOT LEVEL REPAIR	780.	0.44	16097.	936.	0.53	19316.	1092.	0.62	22536.
TOTAL SYSTEM MAINT	100093.		1567041.	120038.		1875926.	139984.		2184811.

	1997			1998			1999		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	131399.	541.48	1915967.	150583.	620.53	2175689.	172568.	711.13	2516263.
PREVENTIVE MAINT	3376.	13.91	135552.	3872.	15.96	151408.	4441.	18.30	168335.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	134776.	555.39	2051519.	154455.	636.49	2347098.	177009.	729.43	2684599.
BASE LEVEL REPAIR	23904.	13.52	416421.	27412.	15.50	477526.	31440.	17.78	547684.
DEPOT LEVEL REPAIR	1249.	0.71	25755.	1432.	0.81	29534.	1642.	0.93	33873.
TOTAL SYSTEM MAINT	159929.		2493695.	183299.		2854158.	210091.		3266156.

	2000			2001			2002		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	197353.	813.27	2877657.	224935.	926.93	3279839.	255313.	1052.12	3722787.
PREVENTIVE MAINT	5083.	20.95	186332.	5799.	23.90	205399.	6588.	27.15	225536.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	202436.	834.21	3063988.	230734.	950.83	3485238.	261901.	1079.26	3948324.
BASE LEVEL REPAIR	35987.	20.35	626894.	41053.	23.22	715157.	46640.	26.38	812473.
DEPOT LEVEL REPAIR	1800.	1.06	30772.	2144.	1.21	44231.	2436.	1.38	50250.
TOTAL SYSTEM MAINT	240302.		3729455.	273932.		4244626.	310977.		4811047.

	2003			2004			2005		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	288486.	1188.81	4206480.	325149.	1339.90	4741078.	365302.	1505.36	5326556.
PREVENTIVE MAINT	7450.	30.70	246744.	8404.	34.63	269287.	9450.	38.94	293172.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	295936.	1219.52	4453224.	333553.	1374.53	5010367.	374752.	1544.31	5619728.
BASE LEVEL REPAIR	52746.	29.83	918841.	59501.	33.65	1036525.	66907.	37.84	1165525.
DEPOT LEVEL REPAIR	2755.	1.56	56829.	3108.	1.76	64107.	3495.	1.98	72086.
TOTAL SYSTEM MAINT	351436.		5428894.	396162.		6110999.	445153.		6857339.

	2006			2007			2008		
LABOR CATEGORY	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST	HOURS	MANPOWER	COST
CORRECTIVE MAINT	408942.	1685.20	5962893.	452583.	1865.04	6599229.	496224.	2044.88	7235567.
PREVENTIVE MAINT	10588.	43.63	318394.	11726.	48.32	343615.	12863.	53.01	368836.
CALL-BACK MAINT	0.	0.00	0.	0.	0.00	0.	0.	0.00	0.
TOTAL SITE MAINT	419530.	1728.83	6281286.	464309.	1913.36	6942844.	509087.	2097.89	7604402.
BASE LEVEL REPAIR	74961.	42.40	1305841.	83016.	46.95	1446157.	91071.	51.51	1586472.
DEPOT LEVEL REPAIR	3915.	2.21	80764.	4336.	2.45	89443.	4757.	2.69	98121.
TOTAL SYSTEM MAINT	498407.		7667891.	551661.		8478442.	604915.		9288994.

	2009		
LABOR CATEGORY	HOURS	MANPOWER	COST
CORRECTIVE MAINT	539845.	2224.72	7871904.
PREVENTIVE MAINT	14001.	57.70	394057.
CALL-BACK MAINT	0.	0.00	0.
TOTAL SITE MAINT	553846.	2282.41	8265960.
BASE LEVEL REPAIR	99126.	56.07	1726788.
DEPOT LEVEL REPAIR	5977.	2.93	106799.
TOTAL SYSTEM MAINT	658949.		10099546.

SYSTEM: EXPANDED (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00

NONRECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	0.	8730739.	68423.
SHIPPING	0.	0.	0.	9011.	7209.
INVENTORY MGT	0.	0.	0.	37200.	0.
SUPPORT EQUIP	0.	0.	0.	97920.	0.
TRAINING	0.	0.	0.	25400.	17400.
DATA MANAGEMENT	0.	0.	0.	7860000.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	0.	16760270.	93032.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	340296.	39458.	50769.	0.	0.
SHIPPING	9011.	7209.	9011.	0.	0.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	23950.	17400.	21750.	0.	0.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	373257.	64067.	81530.	0.	0.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	0.	0.	0.	232752.	92879.
SHIPPING	0.	0.	0.	7209.	7209.
INVENTORY MGT	0.	0.	0.	0.	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	0.	0.	0.	17400.	18150.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	0.	0.	0.	257361.	118238.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	68177.	53308.	228494.	69708.	37717.
SHIPPING	7209.	7209.	7209.	7209.	9011.
INVENTORY MGT	0.	0.	0.	0	0.
SUPPORT EQUIP	0.	0.	0.	0.	0.
TRAINING	17400.	17400.	19600.	17400.	21750.
DATA MANAGEMENT	0.	0.	0.	0.	0.
FACILITIES	0.	0.	0.	0.	0.
ANNUAL TOTAL	92786.	77917.	255303.	94317.	68478.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	107542.	220583.	0.	0.	0.	10340845.
SHIPPING	9011.	9011.	0.	0.	0.	111737.
INVENTORY MGT	0.	0.	0.	0.	0.	37200.
SUPPORT EQUIP	0.	0.	0.	0.	0.	97920.
TRAINING	22500.	21750.	0.	0.	0.	279250.
DATA MANAGEMENT	0.	0.	0.	0.	0.	7860000.
FACILITIES	0.	0.	0.	0.	0.	0.
ANNUAL TOTAL	139053.	251344.	0.	0.	0.	18726956.

SYSTEM: EXPANDED (180)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR10.00

RECURRING LOGISTIC SUPPORT COSTS

COST CATEGORY	1985	1986	1987	1988	1989
SPARES	0.	0.	0.	852884.	897873.
ON-SITE MAINT	0.	0.	0.	70336.	118186.
OFF-SITE MAINT	0.	0.	0.	19928.	35871.
INVENTORY MGT	0.	0.	0.	4650.	4650.
SUPPORT EQUIP	0.	0.	0.	91.	165.
TRAINING	0.	0.	0.	2540.	4280.
DATA MANAGEMENT	0.	0.	0.	93600.	93600.
FACILITIES	0.	0.	0.	78000.	78000.
SITE OPERATION	0.	0.	0.	14835.	26703.
ANNUAL TOTAL	0.	0.	0.	1136864.	1259327.

COST CATEGORY	1990	1991	1992	1993	1994
SPARES	925566.	967082.	1012763.	1012763.	1012763.
ON-SITE MAINT	177685.	225147.	284368.	284368.	284368.
OFF-SITE MAINT	55799.	71741.	91669.	91669.	91669.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	256.	329.	420.	420.	420.
TRAINING	6675.	8415.	10590.	10590.	10590.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	41538.	53406.	68241.	68241.	68241.
ANNUAL TOTAL	1383768.	1502371.	1644302.	1644302.	1644302.

COST CATEGORY	1995	1996	1997	1998	1999
SPARES	1012763.	1012763.	1012763.	1033564.	1068214.
ON-SITE MAINT	284368.	284368.	284363.	331682.	378754.
OFF-SITE MAINT	91669.	91669.	91669.	107612.	123554.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	420.	420.	420.	494.	567.
TRAINING	10590.	10590.	10590.	12330.	14145.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	68241.	68241.	68241.	80109.	91977.
ANNUAL TOTAL	1644302.	1644302.	1644302.	1742040.	1853661.

COST CATEGORY	2000	2001	2002	2003	2004
SPARES	1094384.	1133841.	1176433.	1215575.	1245621.
ON-SITE MAINT	426191.	473400.	520584.	567748.	626677.
OFF-SITE MAINT	139497.	155439.	171382.	187324.	207252.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.
SUPPORT EQUIP	640.	713.	786.	859.	950.
TRAINING	15885.	17625.	19585.	21325.	23500.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.
FACILITIES	78000.	78000.	78000.	78000.	78000.
SITE OPERATION	103845.	115713.	127581.	139449.	154284.
ANNUAL TOTAL	1956692.	2072981.	2192601.	2308530.	2434535.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
SPARES	1406386.	1449142.	1449142.	1449142.	1449142.	24890570.
ON-SITE MAINT	685581.	744463.	744463.	744463.	744463.	9256228.
OFF-SITE MAINT	227181.	247109.	247109.	247109.	247109.	3041032.
INVENTORY MGT	4650.	4650.	4650.	4650.	4650.	102300.
SUPPORT EQUIP	1042.	1133.	1133.	1133.	1133.	13946.
TRAINING	25750.	27925.	27925.	27925.	27925.	347295.
DATA MANAGEMENT	93600.	93600.	93600.	93600.	93600.	2059200.
FACILITIES	78000.	78000.	78000.	78000.	78000.	1716000.
SITE OPERATION	169119.	183954.	183954.	183954.	183954.	2263821.
ANNUAL TOTAL	2691308.	2829976.	2829976.	2829976.	2829976.	43720420.

SYSTEM: EXPANDED (100)
USER: NATIONAL AIR SPACE
DISCOUNT FACTOR:0.00
SYSTEM COST: $ 593656.00

TOTAL LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	0.	3057328.	2445863.	3057328.	2445863.
INSTALLATION	0.	0.	0.	1638000.	1310400.
NONRECURRING	0.	0.	0.	14760270.	91032.
RECURRING	0.	0.	0.	1136864.	1259328.
TOTAL LOGISTIC	0.	0.	0.	17897134.	1352360.
TOTAL PROGRAM	0.	3057328.	2445863.	22592442.	5108622.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	3057328.	0.	0.	0.	0.
INSTALLATION	1638000.	1310400.	1638000.	0.	0.
NONRECURRING	373257.	64067.	81530.	0.	0.
RECURRING	1383768.	1502371.	1644302.	1644302.	1644302.
TOTAL LOGISTIC	1757026.	1566438.	1725832.	1644302.	1644302.
TOTAL PROGRAM	6452354.	2876838.	3363832.	1644302.	1644302.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	0.	2445863.	2445863.	2445863.	2445863.
INSTALLATION	0.	0.	0.	1310400.	1310400.
NONRECURRING	0.	0.	0.	257361.	118238.
RECURRING	1644302.	1644302.	1644302.	1742040.	1853661.
TOTAL LOGISTIC	1644302.	1644302.	1644302.	1999401.	1971899.
TOTAL PROGRAM	1644302.	4090165.	4090165.	5755664.	5728162.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	2445863.	2445863.	3057328.	3057328.	3057328.
INSTALLATION	1310400.	1310400.	1310400.	1310400.	1638000.
NONRECURRING	92786.	77917.	255303.	94317.	68478.
RECURRING	1956692.	2072981.	2192601.	2300530.	2434535.
TOTAL LOGISTIC	2049478.	2150898.	2447904.	2402847.	2503013.
TOTAL PROGRAM	5805741.	5907161.	6815633.	6770576.	7198341.

COST CATEGORY	2005	2006	2007	2008	2009	TOTAL
ACQUISITION	0.	0.	0.	0.	0.	37910872.
INSTALLATION	1638000.	1638000.	0.	0.	0.	20311200.
NONRECURRING	139053.	251344.	0.	0.	0.	18726950.
RECURRING	2691308.	2829976.	2829976.	2829976.	2829976.	43720396.
TOTAL LOGISTIC	2830361.	3081320.	2829976.	2829976.	2829976.	62447348.
TOTAL PROGRAM	4468361.	4719321.	2829976.	2829976.	2829976.	120669416.

CUMULATIVE LIFE CYCLE COSTS BY YEAR

COST CATEGORY	1985	1986	1987	1988	1989
ACQUISITION	0.	3057328.	5503192.	8560520.	11006303.
INSTALLATION	0.	0.	0.	1638000.	2948400.
NONRECURRING	0.	0.	0.	16760270.	16851302.
RECURRING	0.	0.	0.	1136864.	2396192.
TOTAL LOGISTIC	0.	0.	0.	17897134.	19249494.
TOTAL PROGRAM	0.	3057328.	5503192.	28095654.	33204276.

COST CATEGORY	1990	1991	1992	1993	1994
ACQUISITION	14063712.	14063712.	14063712.	14063712.	14063712.
INSTALLATION	4586400.	5896800.	7534800.	7534800.	7534800.
NONRECURRING	17226560.	17290626.	17372156.	17372156.	17372156.
RECURRING	3779960.	5282331.	6926632.	8570934.	10215236.
TOTAL LOGISTIC	21006520.	22572958.	24298790.	25943092.	27587394.
TOTAL PROGRAM	39656620.	42533464.	45897296.	47541576.	49185096.

COST CATEGORY	1995	1996	1997	1998	1999
ACQUISITION	14063712.	16509575.	18955438.	21401300.	23847162.
INSTALLATION	7534800.	7534800.	7534800.	8845200.	10155600.
NONRECURRING	17372156.	17372156.	17372156.	17629516.	17747754.
RECURRING	11859534.	13503840.	15148142.	16890182.	18743842.
TOTAL LOGISTIC	29231694.	30875998.	32520300.	34519700.	36491600.
TOTAL PROGRAM	50830196.	54920360.	59010524.	64766188.	70494344.

COST CATEGORY	2000	2001	2002	2003	2004
ACQUISITION	26293024.	28738886.	31796214.	34853544.	37910872.
INSTALLATION	11466000.	12776400.	14086800.	15397200.	17035200.
NONRECURRING	17840540.	17918456.	18173758.	19268074.	18336552.
RECURRING	20700534.	22773516.	24966118.	27274648.	29709182.
TOTAL LOGISTIC	38541076.	40691976.	43139080.	45542728.	48045740.
TOTAL PROGRAM	76300088.	82207248.	89022880.	95793456.	102991800.

COST CATEGORY	2005	2006	2007	2008	2009
ACQUISITION	37910872.	37910872.	37910872.	37910872.	37910872.
INSTALLATION	18673200.	20311200.	20311200.	20311200.	20311200.
NONRECURRING	18475606.	18726950.	18726950.	18726950.	18726950.
RECURRING	32400490.	35230468.	38060444.	40890420.	43720396.
TOTAL LOGISTIC	50876100.	53957420.	56787396.	59617372.	62447348.
TOTAL PROGRAM	107460160.	112179480.	115009456.	117839432.	120669408.

APPENDIX D

MATHEMATICAL FORMULATION OF THE COST MODEL FOR GROUND EQUIPMENT

CONTENTS

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1. GENERAL DESCRIPTION

ARINC Research Corporation's Life Cycle Cost Model (LCCM) and Facilities Maintenance Cost Model (FMCM) have been adapted to evaluate the economic impact of implementing ground-based Microwave Landing Systems (MLS) given a specific implementation strategy. Six different concepts are evaluated in the current ARINC Research cost study. These six systems include the Small Community MLS (SCMLS), SCMLS with back azimuth, the Basic MLS, Basic MLS with back azimuth, the Redundant Basic MLS, and the Expanded Basic MLS.

The model itself is an expected value model which has been programmed in Fortran IV+ for evaluations using a Digital Equipment Corporation PDP-11/34 minicomputer. The model computes the expected acquisition, installation, and logistic support costs annually and cumulatively for each system concept included in the implementation strategy. The program is designed for flexibility so that data changes can be readily implemented, sensitivity analyses performed, or additional data outputs obtained.

2. PROGRAM FEATURES

The MLS LCCM implementation consists of a common main program, called FACLTY, and eighteen subroutines, each designed to perform a specific function within the model. The routines and their functions are:

(1) ACQCOS - Calculates the cost of acquisition of the MLS ground equipment by year and cumulative.

(2) INSCOS - Calculates the cost of installing the ground equipment by year and cumulative.

(3) LOGCOS - Calls each of the nine routines listed below in order to determine the total nonrecurring (investment), recurring (operation and maintenance), and total logistic support costs of the MLS implementation strategy by year and cumulative.

(a) SPARES - Determines the number and cost of spares required each year based on the expected number of equipment failures in that year.

(b) ONSITE - Determines the cost of on-site repair and preventive maintenance actions based on the expected demand for such actions.

(c) OFSITE - Determines the cost of off-site repair, including materials, labor, and shipping, on the basis of expected demand.

(d) INVENT - Determines the cost associated with introducing and maintaining new coded supply items in inventory and the management cost of maintaining a supply inventory for all coded items stocked at the base and depot levels of repair.

(e) SPTEQP - Determines the cost of purchasing and operating any special equipment sets unique to the system currently under evaluation on the basis of the expected demand for such equipment.

(f) PERSON - Determines the cost of specialized maintenance training required to meet expected corrective maintenance (CM) and preventive maintenance (PM) demands and the cost of additional specialized training required as a result of personnel turnover.

(g) DATMGT - Determines the cost of preparing base and depot level technical documentation as well as the cost of keeping that documentation current.

(h) OPFAC - Determines the cost of operating the base and depot repair facilities.

(i) SYSOP - Determines the cost of operating the ground-based systems.

(4) CUMTOT - Determines the annual and cumulative total equipment costs.

(5) PRTOUT - Prints in table form the expected annual and cumulative labor hours required to maintain each system type evaluated, the number of personnel required to meet that demand, and the cost of those personnel.

(6) DSCONT - Discount constant dollar figures according to guidelines set forth by the FAA.

(7) TABLES - Prints in table form the results of all the above computations.

(8) DATSAV - Accumulates and stores results of individual system evaluation for output at end of program.

(9) UNDSAV - Restores accumulated values to original arrays for output at end of program via the subroutine TABLES.

Seven input data files were used in exercising the ground-based MLS LCCM; one file for each system containing data unique to the system under evaluation, and one user file called REPFAC tailored to the associated repair facilities. The system and user file names are specified at the beginning of the program's exercise from the teletype terminal keyboard, as are the discount rate and the base year to be used for discounting purposes. The program then opens the designated files and reads them to obtain the specific data parameters used in the evaluation.

The specific outputs of the model, as dictated by the TABLES module, are:

(1) The total acquisition cost of the MLS ground equipment by year and cumulative per the given implementation strategy.

(2) The total installation cost of the MLS ground equipment by year and cumulative.

(3) The total nonrecurring logistic support cost of the MLS ground equipment by year.

(4) The total recurring logistic support cost of the MLS ground equipment by year.

(5) The total logistic support cost (nonrecurring plus recurring) of the MLS ground system by year and cumulative.

(6) The total cost of the MLS ground equipment by year and cumulative.

(7) The detailed cost element breakdowns of the nonrecurring, recurring, and total logistic support costs of the MLS ground equipment by year.

3. MODEL FORMULATION

The following describes the mathematical formulation of the ground-based MLS LCCM which has been implemented into the program FACLTY. The model computes on an annual and cumulative basis the acquisition, installation, and logistic support costs and their totals for a given implementation schedule of the six MLS concepts in the time period 1985-2009.

The parameter definitions used in the model are presented after each set of equations as well as in Appendix C.

3.1 Acquisition Costs (ACQCOS)

The acquisition costs are determined by the number of MLS ground systems purchased each year and the average unit cost of the systems during the year (reflecting learning curves and amortization costs, if applied). The acquisition costs for year i are given by:

$$ACOS_i = (GSYS_i)(FUCOS_i)$$

where:

$$GSYS_i = NNGS_i + NRGS_i$$

$$FUCOS_i = (UCOS + AMCOS)(1+DIST);\ i \leq 2$$

$$= (UCOS)(1+DIST);\ i > 2$$

The cumulative acquisition cost is simply:

$$TCOSA_i = \sum_{j=1}^{i} ACOS_i$$

Variables are:

$GSYS_i$ = no. of specified ground systems purchased in year i = program internal

$NNGS_i$ = no. of ground systems of specified type to be installed in new sites in year i

$NRGS_i$ = no. of ground systems of specified type to be installed in retrofit sites in year i

$FUCOS_i$ = average system cost in year i

UCOS = OEM unit cost of full system

AMCOS = amortization cost

DIST = percentage markup by distributor on full system

3.2 Installation Costs (INSCOS)

The installation cost in the i'th year is determined by the number of MLS units installed in new ground sites or retrofit into existing sites that year multiplied by the appropriate per unit installation rate. The resultant installation cost equation is given by:

$$ICOS_i = [(NRGS_i)(RICOS)+(NNGS_i)(INCOS)]$$

The cumulative installation cost is given by:

$$TCOSI_i = \sum_{j=1}^{i} ICOS_i$$

Variables are:

$NRGS_i$ = no. of ground systems of specified type to be installed in retrofit sites in year i

RICOS = retrofit installation cost per system

$NNGS_i$ = no. of ground systems of specified type to be installed in new sites in year i

INCOS = new installation cost per system

3.3 Logistic Support Costs (LOGCOS)

The logistic support cost of the system(s) under evaluation is composed of the sum of nine cost elements, each having a nonrecurring (investment) and recurring (operation and maintenance) cost component. These nine cost elements, in order of evaluation are:

1) Spares

2) System maintenance at the system site

3) System repair at the base and depot levels

4) Inventory entry and supply management

5) Special support equipment

6) Training of repair personnel

7) Data management and technical documentation

8) Operation of repair facilities

9) Operation of system sites

Hence, the logistic support cost in the i'th year is given by:

$$TLCOS_i = \sum_{j=1}^{9} [NRCOS_{i,j} + RLCOS_{i,j}],$$

with $NRCOS_{i,j}$ representing the nonrecurring costs and $RLCOS_{i,j}$ representing the recurring costs. Similarly, the cumulative nonrecurring, recurring, and total logistic support costs for year i are given by:

$$TCOSN_i = \sum_{j=1}^{i} TNRCOS_j$$

$$TCOSR_i = \sum_{j=1}^{i} TRLCOS_j$$

where:

$$TNRCOS_j = \sum_{k=1}^{9} NRCOS_{j,k}$$

$$TRLCOS_j = \sum_{k=1}^{9} RLCOS_{j,k}$$

The following paragraphs present the methodology for determining the individual cost elements and their components.

3.3.1 Initial and Replacement Spares (SPARES)

This cost element consists of the expenses associated with the procurement of the spares inventory. The nonrecurring component is the expenditure in the i'th year to purchase the spares required to satisfy the expected demand with a given level of spares sufficiency. In determining the nonrecurring costs, assumptions which should be noted are:

(1) A minimum of one spare of each type of the principal .ules, or LRUs, and sub-modules, or SRUs, is assumed for each base.

(2) A minimum of one spare of each type LRU and SRU is assumed for each depot.

The recurring spares cost represents the cost of purchasing additional spares to replace those lost to the logistic system through condemnation and attrition.

The nonrecurring component is given by:

$$NRCOS_{i,1} = \sum_{j=1}^{NLRU} [(NLSPRS_{i,j})(LUCOS_j) + \sum_{k=1}^{NSRU_j} (NSSPRS_{i,j,k})(SUCOS_{j,k})]$$

where, for nonrepairable LRUs:

$$NLSPRS_{i,j} = \{INT[(NOB_i)(YDUM+SUF(2)\sqrt{YDUM})] + INT[(NOD_i)(ZDUM+SUF(2)\sqrt{ZDUM})] + INT(TDUM)+INT(SDUM)+INT(RDUM)\}(ISPR_j) - NSPRL_j$$

$$YDUM = (TFOH_i)(FBLRU)(BSOBL)/((NOB_i)(LMTBF_j))$$

$$ZDUM = (TFOH_i)(FBLRU)(BSODL)/((NOD_i)(LMTBF_j))$$

$$TDUM = (TFOH_i)(FBLRU)(OSBL)/LMTBF_j$$

$$SDUM = (TFOH_i)(FBLRU)(OSDL)/LMTBF_j$$

$$RDUM = (TFOH_i)(ROP)/LMTBF_j$$

and:

$$FBLRU = BIT + (1-BIT)(RTSS)$$

$$TFOH_i = (AFHR)(NS_i)$$

$$NS_i = \sum_{j=1}^{i} GSYS_j$$

where, for repairable LRUs:

$$NLRSPRS_{i,j} = \{\{Max[INT[(NOB_i)(YDUM + SUF(2)\sqrt{YDUM})], (MINB)(NOB_i)/LCOML_j]\} + \{Max[INT[(NOD_i)(ZDUM + SUF(2)\sqrt{ZDUM})], (MINB)(NOD_i)/LCOML_j]\}\}(ISPR_j) - NSPRL_j$$

and:

$$YDUM = (TFOH_i)(FBLRU)(RTS_j)(BMT)/[(NOB_i)(LMTBF_j)]$$

$$ZDUM = (TFOH_i)(FBLRU)(1-RTS_j)(DMT)/[(NOD_i)(LMTBF_j)]$$

where, for nonrepairable SRUs:

$$NSSPRS_{i,j,k} = \{INT[(NOB_i)(XDUM + SUF(3)\sqrt{XDUM})] + INT[(NOD_i)(XDUM+SUF(3)\sqrt{YDUM})] + INT(WDUM)+INT(TDUM)+INT(SDUM)\}(ISPRB_{j,k}) - NSPRB_{j,k}$$

and:

$$XDUM = (TFOH_i)(FBLRU)(RTS_j)(BSOB)/[(NOB_i)(SMTBF_{j,k})]$$

$$YDUM = (TFOH_i)(FBLRU)(1-RTS_j)(BSOD)/[(NOD_i)(SMTBF_{j,k})]$$

$$WDUM = (TFOH_i)(FBLRU)(RTS_j)(OSB)/SMTBF_{j,k}$$

$$TDUM = (TFOH_i)(FBLRU)(1-RTS_j)(OSD)/SMTBF_{j,k}$$

$$SDUM = (TFOH_i)(ROP)/SMTBF_{j,k}$$

where, for repairable SRUs:

$$NSSPRS_{i,j,k} = \{\{Max[INT[(NOB_i)(XDUM + SUF(3)\sqrt{XDUM})], (XMINB)(NOB_i)/LCOMS_{j,k}](NOSRU_{j,k})\} + Max[INT[(NOD_i)(YDUM + SUF(3)\sqrt{YDUM})], (XMINB)(NOD_i)/LCOMS_{j,k}](NOSRU_{j,k})\}\}(ISPRB_{j,k}) - NSPRB_{j,k}$$

and:

$$XDUM = (TFOH_i)[(FBLRU)(RTS_j)(RTSB_{j,k})(BMT)]/[(NOB_i)(SMTBF_{j,k})]$$

$$YDUM = (TFOH_i)[(FBLRU)[(RTS_j)(1-RTSB_{j,k}) +(1-RTS_j)](DMT)]/[(NOD_i)(SMTBF_{j,k})]$$

The recurring component is given by:

$$RLCOS_{i,1} = \sum_{j=1}^{NLRU} [(RLSPRS_{i,j})(LUCOS_j)(1+LMKUP) + \sum_{k=1}^{NSRU_j} (RSSPRS_{j,k})$$
$$(SUCOS_{j,k})(1+SMKUP)]$$

where:

$$RLSPRS_{i,j} = INT[(TFOH_i)(COND_j)/LMTBF_j](ISPR_j)$$

$$RSSPRS_{i,j,k} = INT[(TFOH_i)(CONDB_{j,k})(NOSRU_{j,k})/SMTBF_{j,k}](ISPRB_j)$$

Variables are:

NOB_i = no. of bases in year i

NOD_i = no. of depots in year i

SUF(2) = LRU spares sufficiency factor

$NSPRL_j$ = no. LRU_j spares purchased prior to year i = program internal

BSOBL = base LRU stocking objective

BSODL = depot LRU stocking objective

OSBL = average LRU order/ship time, base

OSDL = average LRU order/ship time, depot

ROP = requirements objectives period

$ISPR_j$ = spare flag for LRU_j

BIT = fraction of failures isolated to LRU by Built-In Test Equipment

RTSS = fraction of failures isolated to LRU level at base without using BITE

AFHR = average annual system operating hours

NS_i = no. of systems in operation in year i = program internal

$GSYS_i$ = number of systems purchased in year i = program internal

NLRU = no. of LRUs in system

$LUCOS_j$ = unit cost of jth LRU

$NSRU_j$ = no. of SRU types in j'th LRU

$SUCOS_{j,k}$ = unit cost of k'th SRU in j'th LRU

MINB = minimum no. of each type LRU spare

$LCOMJ_j$ = number of system types to which LRU_j is common

RTS_j = fraction of LRU_j failures isolated to SRU at base

BMT = base turnaround time

$LMTBF_j$ = mean time between failures of j'th LRU

DMT = depot turnaround time

SUF(3) = SRU spares sufficiency factor

$ISPRB_{j,k}$ = spare flag for $SRU_{j,k}$

BSOB = base SRU stocking objective

$SMTBF_{j,k}$ = mean time between failures of $SRU_{j,k}$

BSOD = depot SRU stocking objective

OSB = average SRU order/ship time, base

OSD = average SRU order/ship time, depot

XMINB = minimum no. of each type SRU spares

$LCOMS_{j,k}$ = no. of LRUs to which $SRU_{j,k}$ is common

$COND_j$ = fraction of LRU_j failures lost to condemnation

$CONDB_{j,k}$ = fraction of $SRU_{j,k}$ failures lost to condemnation

$NOSRU_{j,k}$ = no. of like SRUs of type K in LRU_j

LMKUP = distributor's markup on LRUs

SMKUP = distributor's markup on SRUs

3.3.2 On-Site Maintenance (ONSITE)

This cost element represents the expected expenditures in performing maintenance at the ground system sites. This element contains only a recurring cost component, i.e., $NRCOS_{i,2} = 0$, and represents the costs associated with remove and replace actions, repair actions taking place at the site, preventive maintenance actions, and travel to and from the system site for CM and PM. The cost is determined as follows:

$$RLCOS_{i,2} = MCOST_i + PMCOST_i + CBCOST_i + CTRAV_i + PTRAV_i$$

where:

$$CMCOST_i = (CMHRS_i)(SLR_{NSCAT})/PMJ$$

$$PMCOST_i = (PMHRS_i)(SLR_{NSCAT})/PMJ + (NFC)(CPFC)$$

$$CBCOST_i = (CBHRS_i)(OTSLR_{NSCAT})/PMJ$$

$$CMPER_i = [(CMHRS_i)/((PMJ)(PRODJ))](MINJP)$$

$$PMPER_i = [(PMHRS_i)/((PMJ)(PRODJ))](MINJP)$$

$$CBPER_i = [(CBHRS_i)/((PMJ)(PRODJ))]$$

$$\begin{aligned} PTRAV_i = (2) \sum_{j=1}^{3} [(NRL_{i,j})[(260+104(NC))(FI_1)+52(FI_2)+12(FI_3) \\ +4(FI_4)+2(FI_5)+(FI_6)+(780+312(NC))(FI_7) \\ +(130+52(NC))(FI_8)+104(FI_9)+26(FI_{10})](PMILES)(CPMI)] \end{aligned}$$

$$CTRAV_i = (TFOH_i)(CMILES)(CPMI)/UMTBF$$

and:

$$CMHRS_i = \sum_{j=1}^{3} \{(NSHFT_j)[(CMDEM_j/NSHFT_j) + SUF(1)\sqrt{CMDEM_j/NSHFT_j}]\}$$

$$CMDEM_j = (RSF_j + (RLF_j)(1-PCON_j))(SMMHC)(SHFT)$$

$$NSHFT_j = 5(NDS_j) + 2(NWS_j)$$

$$PMHRS_j = \sum_{i=1}^{3} [(NRL_{ij}) [(260 + 104(NC))(2(TRTD) + PMMH_1)(FI_1) + (52)(2(TRT) + PMMH_2)(FI_2) + (12)(2(TRT) + PMMH_3)(FI_3) + (4)(2(TRT) + PMMH_4)(FI_4) + (2)(2(TRT) + PMMH_5)(FI_5) + (2(TRT) + PMMH_6)(FI_6) + (780 + 312(NC))(2(TRTD) + PMMH_7)(FI_7) + (130 + 52(NC))(2(TRT) + PMMH_8)(FI_8) + (104)(2(TRT) + PMMH_9)(FI_9) + (26)(2(TBT) + PMMH_{10})(FI_{10})](SHFT)]$$

$$CBHRS_j = (RLF_2)(PCON_2)(SMMHP)$$

and:

$$RSF_j = \sum_{k=1}^{3} (NRL_{i,j})[(PD_k)(XNOFD)(MS_k) + (PE_k)(XNOFW)(MES_k)]$$

$$RLF_j = (XNOF)(NRL_{i,j}) - RSF_j$$

$$SMMHC = 2(TRT) + FITT + (FTS)(MTTR) + (1-FTS)(MTRR)$$

$$SMMHP = 2(TRTP) + FITT + (FTS)(MTTR) + (1-FTS)(MTRR)$$

$$XNOF = AFHR / UMTBF$$

$$XNOFD = (260)(DFHR)/UMTBF$$

$$XNOFW = XNOF - XNOFD$$

$$TFOH_i = (AFHR)(NS_i)$$

$$NS_i = \sum_{j=1}^{i} GSYS_j$$

Variables are:

$CMPER_i$ = no. of personnel required to fulfill expected corrective maintenance (CM) demands in year i = program internal

$PMPER_i$ = no. of personnel required to fulfill expected preventive maintenance (PM) demands in year i = program internal

$CBPER_i$ = no. of personnel required to fulfill expected call-back maintenance (CB) demands in year i = program internal

$CMHRS_i$ = no. of expected CM hours required in year i = program internal

$PMHRS_i$ = no. of expected PM hours required in year i = program internal

$CBHRS_i$ = no. of expected CB hours required in year i = program internal

$CTRAV_i$ = cost of travel to sites for CM in year i = program internal

$PTRAV_i$ = cost of travel to sites for PM in year i = program internal

$CMDEM_j$ = expected CM demand for restoration level j in year i = program internal

$NSHFT_j$ = no. of shifts per week, restoration level j = program internal

NDS_j = no. of daily weekday shifts, restoration level j

NWS_j = no. of daily weekend shifts, restoration level j

RSF_j = regular shift maintenance demands for systems having restoration level j = program internal

RLF_j = non-regular shift maintenance demands for systems having restoration level j = program internal

$PCON_j$ = probability of contacting maintenance personnel given restoration level j

SMMHC = labor-hours required per corrective maintenance action = program internal

SHFT = shift differential identifier = program internal

PMJ = available hours per man per year

PRODJ = productivity of technicians performing maintenance at system site

MINJP = minimum no. of technicians required to meet staffing requirements

SLR_{NSCAT} = loaded annual salary for technician of skill level NSCAT

NSCAT = technician level required fc repair of system under evaluation

NFC = no. of flight checks per year

CPFC = cost per flight check

NC = weekend shift identifier = program internal

SUF(1) = sufficiency factor for repair personnel

TRTD = avg. authorized travel time to site for daily PM

PMMH = avg. preventive maintenance labor-hours

FI = preventive maintenance identifier = program internal

TRT = avg. authorized travel time from central location to system site

SMMHP = labor-hours required per call-back maintenance action

$OTSLR_{NSCAT}$ = loaded overtime rate for technician of skill level NSCAT

$NRL_{i,j}$ = no. of sites having restoration level j in year i

PD_k = daily failure allocation factor = program internal

XNOFD = avg. no. of weekday failures per year = program internal

MS_k = daily maintenance shift identifier = program internal

PE_k = weekend failure allocation factor = program internal

XNOFW = avg. no. of weekend failures per year = program internal

MES_k = weekend maintenance shift identifier = program internal

XNOF = avg. no. of failures in year i = program internal

FITT = avg. labor hours to fault isolate and test failed unit at site

FTS = fraction of failures repaired at site

MTTR = mean time to repair failure at site

MTRR = mean time to remove and replace failed unit at site

TRTP = avg. authorized travel time to site for call-backs

UMTBF = avg. mean time between system failures = program internal

DFHR = daily operating hours per system type

AFHR = avg. annual operating hours per system type

$TFOH_i$ = avg. annual operating hours for systems in operation in year i = program internal

CMILES = avg. distance traveled to sites for CM

CPMI = cost per mile

PMILES = avg. distance traveled to sites for PM

NS_i = no. of systems in operation in year i = program internal

$GSYS_i$ = no. of systems purchased in year i = program internal

3.3.3 Off-Site Maintenance (OFSITE)

The initial system shipping costs, expected material, labor, and parts shipping costs associated with performing corrective maintenance at the base and depot locations are represented by this cost element. Nonrecurring costs include only the cost of shipping each system to its installation site; all other costs are included in the recurring costs. The nonrecurring cost component is given by:

$$NRCOS_{i,3} = (SYSWT)\ (GSYS_i)\ [(YMIL)\ (SSHC) + (XMIL)\ (SHC)]$$

Variables are:

SYSWT = total system weight (lb.)

$GSYS_i$ = no. of systems purchased in year i = program internal

YMIL = average no. of shipping zones between base and depot

SSHC = shipping rate per lb. between base and depot

XMIL = average no. of shipping zones to first destination

SHC = shipping rate per lb. to first destination

The recurring cost component is determined by:

$$RLCOS_{i,3} = TMAT_i + TLABOR_i + TSHIP_i$$

where:

$$TMAT_i + TFOH_i \left[\sum_{j=1}^{NLRU} \left[(FBLRU)(RTS_j)(RTLB_j)(BMC_j) + ((RTS_j)(1-RTLB_j) + (1-RTS_j))(DMC_j)\right)/LMTBF_j\right.$$

$$+ \sum_{k=1}^{NSRU_j} (NOSRU_{j,k})\left[(FBLRU)(RTSB_{j,k})(BMCS_{j,k})(RTS_j) + \left[(RTS_j)(1-RTSB_{j,k}) + (1-RTS_j))(DMCS_{j,k})\right]\right]/SMTBF_{j,k}\left.\right]\left.\right]$$

$$TLABOR_i = (BPERS_i)(BLR)(PRODB) + (DPERS_i)(DLR)(PRODD)$$

$$TSHIP_i = (PACK)(TFOH_i)\left[(XLTTR_i + XSTTR_j)\left[(YMIL)(SSHC)+(XMIL)(SHC)\right] + (XLSHP_i + XSSHP_i)\right]$$

and:

$$BPERS_i = (TFOH_i)(BHOURS_i)/\left[(PMB)(PRODB)\right]$$

$$DPERS_i = (TFOH_i)(DHOURS_i)/\left[(PMD)(PRODD)\right]$$

$$BHOURS_i = (FBLRU) \sum_{j=1}^{NLRU} \left\{\left[(RTS_j)(LMTTR_j)(RTLB_j)(1-ITWL_j)/LMTBF_j\right] + \sum_{k=1}^{NSRU_j}\left[(NOSRU_{j,k})(RTS_j)(RTSB_{j,k})(SMTTR_{j,k})(1-ITWS_{j,k})/SMTBF_{j,k}\right]\right\}$$

$$DHOURS_i = (FBLRU) \sum_{j=1}^{NLRU} \left\{\left[(RTS_j)(LMTTR_j)(1-RTLB_j)(1-ITWL_j)/LMTBF_j\right] + \sum_{k=1}^{NSRU_j}\left[(NOSRU_{j,k})((RTS_j)(1-RTSB_{j,k}) + (1-RTS_j))(SMTTR_{j,k})(1-ITWS_{j,k})/SMTBF_{j,k}\right]\right\}$$

$$XLTTR_i = \sum_{j=1}^{NLRU} (WT_j)(COND_j)/LMTBF_j$$

$$XSTTR_i = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_j} (WTB_{j,k})(CONDB_{j,k})(NOSRU_{j,k})/SMTBF_{j,k}$$

$$XLSHP_i = \sum_{j=1}^{NLRU} [(WT_j)[(FBLRU)[(1-RTS_j)+(RTS_j)(1-RTLB_j)]$$

$$(2)(YMIL)(SSHC)(1-ITWL_j)+[(FBLRU)(1-RTS_j)$$

$$((YMIL)(SSHC)+(XMIL)(SHC))(ITWL_j)]]/LMTBF_j]$$

$$XSSHP_i = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_j} (NOSRU_{j,k})[(WTB_{j,k})[(FBLRU)(RTS_j)(1-RTSB_{j,k})(2)$$

$$(YMIL)(SSHC)(1-ITWS_{j,k})+(FBLRU)(RTS_j)((YMIL)(SSHC)+$$

$$(XMIL)(SHC))(ITWS_{j,k})]/SMTBF_{j,k}]$$

$$TFOH_i = (AFHR)(NS_i)$$

$$FBLRU = BIT + (1-BIT)(RTSS)$$

Variables are:

$NLRU$ = no. of LRUs in avionics system

RTS_j = fraction of LRU_j failures isolated to SRU at base

$RTLB_j$ = fraction of repairable LRU_j failures repaired at base

BMC_j = average base materials cost per maintenance action on j'th LRU

DMC_j = average depot materials cost per maintenance action on j'th LRU

$LMTBF_j$ = mean time between failures of j'th LRU

$NSRU_j$ = no. of SRU types in j'th LRU

$NOSRU_{j,k}$ = no. of like SRUs of type k in LRU_j

$RTSB_{j,k}$ = fraction of repairable $SRU_{j,k}$ repaired at base

$BMCS_{j,k}$ = average base materials cost per maintenance action on $SRU_{j,k}$

$DMCS_{j,k}$ = average depot materials cost per maintenance action on $SRU_{j,k}$

$SMTBF_{j,k}$ = mean time between failures of $SRU_{j,k}$

$TFOH_i$ = average annual operating hours of all systems in operation in year i = program internal

$BPERS_i$ = no. base repair personnel required to meet expected demand in year i = program internal

$DPERS_i$ = no. depot repair personnel required to meet expected demand in year i = program internal

BLR = average annual salary of base repair personnel

PMB = available hours per base repair person per year

PRODB = productivity of base repair personnel

DLR = average annual salary of depot repair personnel

PMD = available hours per depot repair person per year

PRODD = productivity of depot repair personnel

PACK = packaging factor = packed wt./unpacked wt.

YMIL = average no. shipping zones between base and depot

SSHC = shipping rate per lb. between base and depot

XMIL = average no. of shipping zones to first destination

SHC = shipping rate per lb. to first destination

$LMTTR_j$ = mean time to repair j'th LRU

$ITWL_j$ = repair/throw-away flag for j'th LRU

$SMTTR_{j,k}$ = mean time to repair $SRU_{j,k}$

$ITWS_{j,k}$ = repair/throw-away flag for $SRU_{j,k}$

WT_j = weight of j'th LRU

$COND_j$ = fraction of failed LRU_j lost to condemnation

$WTB_{j,k}$ = weight of $SRU_{j,k}$

$CONDB_{j,k}$ = fraction of failed $SRU_{j,k}$ lost to condemnation

AFHR = average monthly flight operating hours

NS_i = no. of systems in operation in year i = program internal

BIT = fraction of failures isolated to LRU by Built-In Test Equipment

RTSS = fraction of failures isolated to LRU at base without using BITE

3.3.4 Inventory Entry and Supply Management (INVENT)

This cost element represents the cost associated with introducing and maintaining new coded supply items in the user inventory and the management cost of maintaining a supply inventory for all of the coded items that are stocked at the repair sites. The first year's inventory entry cost is treated as a nonrecurring cost ($NRCOS_{i,4}$); the supply management cost is treated as a recurring cost throughout ($RLCOS_{i,4}$). The resultant components are given by:

$$NRCOS_{i,4} = (IAMC)(NNIC); \quad i = 1$$
$$= 0 \quad ; \quad i \neq 1$$

$$RLCOS_{i,4} = (NNIC)(HOLD)$$

Variables are:

IAMC = cost of introducing each new coded item

NNIC = no. of inventory coded items that are new

HOLD = average annual holding cost per item type

3.3.5 Special Support Equipment (SPTEQP)

Included in this cost element are the nonrecurring costs of purchasing special test equipment ($NRCOS_{i,5}$) and the recurring costs of operating that equipment ($RLCOS_{i,5}$). It is assumed in the model that the test equipment is unique to the systems being evaluated. It is further assumed that there will be a minimum of one of each type of support equipment at each base and depot facility. The nonrecurring and recurring costs of special support equipment in the i'th year, assuming that $NSEB_m$ and $NSED_m$ units of the m'th equipment type have been purchased prior to year i at the base and depot level, are given by:

$$NRCOS_{i,5} = NNSEB_i + NNSED_i$$

where:

$$NNSEB_i = \sum_{m=1}^{JSEB} [Max\{INT[(TFOH_i)(BFIT)(UTILB_m)/((UMTBF)$$

$$(AVALB_m)(BETA_m))], (MINSEB)(NOB_i)/LCOMB_m\} - NSEB_m]$$

$$(USECOB_m)$$

$$NSSED_i = \sum_{m=1}^{JSED} [Max\{INT[(TFOH_i)(DFIT)(UTILD_m)/((UMTBF)$$

$$(AVALD_m)(DETA_m))], (MINSED)\ (NOD_i)/LCOMD_m\}$$

$$- NSED_m](USECOD_m)$$

$$TFOH_i = (AFHR)(NS_i)$$

$$BFIT = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_j} [(1-FTS)(FBLRU)(RTS_j)(RTSB_{j,k})(SFITT_{j,k})$$

$$(NOSRU_{j,k})/(SMTBF_{j,k})]$$

$$DFIT = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_J} \{(1-FTS)[(1-BIT)(1-RTSS) + (FBLRU)((1-RTS_k)$$

$$+(RTS_k)(1-RTSB_{j,k}))](SFITT_{j,k})(NOSRU_{j,k})/SMTBF_{j,k}\}$$

$$FBLRU = BIT + (1-BIT)(RTSS)$$

and:

$$RLCOS_{i,5} = RNSEB_i + RNSED_i$$

where:

$$RNSEB_i = \sum_{m=1}^{JSEB} \{ Max [(TFOH_i)(BFIT)(UTILB_m)(SECOB_m)/((UMTBF)$$

$$(AVALB_m)(BETA_m)), (MSEBO_m)(NSEB_m)]\}$$

$$RNSED_i = \sum_{m=1}^{JSED} \{Max[(TFOH_i)(DFIT)(UTILD_m)(SECOD_m)/((UMTBF)$$

$$(AVALD_m)(DETA_m)), (MSEDO_m)(NSED_m)]\}$$

Variables are:

$JSEB$ = no. of different types base support equipment

$TFOH_i$ = avg. annual operating hours of systems in operation in year i = program internal

$UTILB_m$ = utilization rate of m'th type base support equipment

$UMTBF$ = mean time between system failures = program internal

$BETA$ = m'th type base support equipment hours available per month

$AVALB_m$ = availability of m'th type support equipment, base

$MINSEB$ = minimum no. of each type support equipment, base

$LCOMB_m$ = no. system types to which m'th type base support equipment is common

$USECOB_m$ = unit cost of m'th type base support

NOB_i = no. of bases in year i

NOD_i = no. of depots in year i

$UTILD_m$ = utilization rate of m'th type depot support equipment

$DETA_m$ = m'th type depot support equipment hours available per month

$AVALD_m$ = availability m'th type depot support equipment

$MINSED$ = minimum no. of each type depot support equipment

$LCOMD_m$ = no. of avionics unit types to which m'th type depot support equipment is common

$USECOD_m$ = unit cost of m'th type depot support equipment

$AFHR$ = avg. annual operating hours per system

NS_i = no. of systems in operation in year i = program internal

$NLRU$ = no. of LRUs in system

$NSRU_j$ = no. of SRU types in j'th LRU

FTS = fraction of failures repaired on-site

RTS_j = fraction of LRU_j failures isolated to SRU at base

$RTSB_{j,k}$ = fraction of repairable $SRU_{j,k}$ repaired at base

$SFITT_{j,k}$ = avg. labor-hours to fault isolate and test failed $SRU_{j,k}$

$NOSRU_{j,k}$ = no. of like SRUs of type k in j'th LRU

$SMTBF_{j,k}$ = mean time between failures of $SRU_{j,k}$

BIT = fraction of failures isolated to LRU by Built-In Test Equipment

RTSS = fraction of failures isolated to LRU at base without using BITE

$SECOB_m$ = m'th type base support equipment operating cost

$MSEBO_m$ = minimum annual m'th type base support equipment operating cost

$SECOD_m$ = m'th type depot support equipment operating cost

$MSEDO_m$ = minimum annual m'th type depot support equipment operating cost

3.3.6 Training (PERSON)

The training cost consists of the specialized maintenance training required to meet the expected corrective and preventive maintenance demands ($NRCOS_{i,6}$) and the recurrent cost of additional specialized training resulting from the turnover of repair personnel ($RLCOS_{i,6}$). It is assumed that a minimum of one person per maintenance site will receive training. The training costs incurred in year i, then, assuming that NPERJ technicians, NPERB base personnel, and NPERD depot personnel have been trained prior to year i are:

$$NRCOS_{i,6} = (NJPER_i)(TCOSJ_{NSCAT}) + (NBPER_i)(TCOSB) + (NDPER_i)(TCOSD)$$

where:

$NJPER_i$ = DMPERS - NPERJ

$NBPER_i$ = BASEP - NPERB

$NDPER_i$ = DEPOTP - NPERD

and:

$$DMPERS = INT(CMPER_i + PMPER_i + CBPER_i + .999)$$

$$BASEP = INT(BPERS_i + .999)$$

$$DEPOTP = INT(DPERS_i + .999)$$

where:

$$RLCOS_{i,6} = (NPERJ)(TCOSJ_{NSCAT})(TRJ_{NSCAT}) + (NPERB)(TCOSB)(TRB) + (NPERD)(TCOSD)(TRD)$$

Variables are:

$NJPER_i$ = number of technicians trained in year i = program internal

$NBPER_i$ = number of base repair personnel trained in year i = program internal

$NDPER_i$ = number of depot repair personnel trained in year i = program internal

$TCOSJ_{NSCAT}$ = cost to train technician of skill level NSCAT

NSCAT = technician level required for repair of system under evaluation

TCOSB = training cost per base level repair person

TCOSD = training cost per depot level repair person

$CMPER_i$ = number of technicians required to meet expected CM demand in year i = program internal, see Section 3.3.2

$PMPER_i$ = number of technicians required to meet expected PM demand in year i = program internal, see Section 3.3.2

$CBPER_i$ = number of technicians required to meet expected CB demand in year i = program internal, see Section 3.3.2

$BPERS_i$ = number of base repair personnel required to meet expected demand in year i = program internal, see Section 3.3.3

$DPERS_i$ = number of depot repair personnel required to meet expected demand in year i = program internal see Section 3.3.3

TRJ_{NSCAT} = turnover rate for technicians of skill level NSCAT

TRB = turnover rate for base repair personnel

TRD = turnover rate for depot repair personnel

3.3.7 Data Management and Technical Documentation (DATMGT)

The data management and technical documentation element consists of the nonrecurring cost ($NRCOS_{i,7}$) associated with the preparation of base and depot level documentation and the recurring cost ($RLCOS_{i,7}$) associated with keeping that documentation current. These costs are given by the following equations:

$$NRCOS_{i,7} = (CPP)[(NPBD)(NNBAS_i)+(NPDD)(NNDEP_i)]$$

where:

$$NNBAS_i = NOB_i \quad ; \; i = 1$$
$$= NOB_i - NOB_{(i-1)} ; \; i \neq 1$$
$$NNDEP_i = NOD_i \quad ; \; i = 1$$
$$= NOD_i - NOD_{(i-1)} ; \; i \neq 1$$

and:

$$RLCOS_{i,7} = (CPNP)[(NNPBD)(NOB_i)+(NNPDD)(NOD_i)]$$

Variables are:

CPP = cost per page, original technical documentation

NPBD = no. of pages base level documentation

NPDD = no. of pages depot level documentation

NOB_i = no. of bases in year i

NOD_i = no. of depots in year i

CPNP = cost per new page of technical documentation

NNPBD = no. of new pages base level documentation

NNPDD = no. of new pages depot level documentation

3.3.8 Facilities

The facilities costs are considered to consist of the recurring operating costs of the repair facilities (e.g., space rent, electricity, general tools, etc.). It is assumed that no new support facilities will be required for the system; hence, $NRCOS_{i,8} = 0$. The recurring cost ($RLCOS_{i,8}$) is then given by:

$$RLCOS_{i,8} = (FOCB)(NOB_i) + (FOCD)(NOD_i)$$

Variables are:

FOCB = annual base facilities cost attributable to system being analyzed

FOCD = annual depot facilities cost attributable to system being analyzed

NOB_i = number of base maintenance sites, year i

NOD_i = number of depot maintenance sites, year i

3.3.9 System Operation (SYSOP)

The cost of operating the ground systems is represented by this cost element, which consists solely of a recurring cost component ($NRCOS_{i,9} = 0$). This cost is determined by the following formula:

$$RLCOS_{i,9} = (TFOH_i)(NOKWHR)(CPKWHR)/AFHR$$

Variables are:

$TFOH_i$ = average annual operating hours of all systems in operation in year i = program internal

NOKWHR = number of kilowatt hours used annually by system under evaluation

CPKWHR = cost per kilowatt hour

AFHR = avg. annual operating hours per system type

APPENDIX E

LIFE-CYCLE-COST MODEL
FOR GROUND EQUIPMENT

```
C                          PROGRAM FACLTY
C
C        THE PROGRAM FACLTY DETERMINES THE TOTAL LIFE CYCLE COSTS OF
C        GROUND MLS INSTALLATIONS.  DATA IS INPUT TO THE PROGRAM BY
C        MEANS OF THE USER TERMINAL, A REPAIR FACILITY FILE (REPFAC), AND
C        A SYSTEM FILE (SFILE).  THE PROGRAM USES THE DATA TO CALCULATE
C        ANNUAL ACQUISITION COSTS, INSTALLATION COSTS, AND LOGISTIC SUP-
C        PORT COSTS, WHICH ARE THEN OUTPUT IN TABULAR FORM IN BOTH CON-
C        STANT AND DISCOUNTED DOLLARS.
C
      PROGRAM FACLTY
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25),TCOSA(25)
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1             NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/BASDEP/BLR,BMT,DLR,DMT,FOCB,FOCD,SHC,SSHC,XMIL,YMIL
      COMMON/BASSPT/AVALB(10),BETA(10),BFIT,JSEB,LCOMB(10),MINSEB,
     1             MSEBO(10),SECOB(10),USECOB(10),UTILB(10)
      COMMON/CAT/CLCC,CPROG(25),TNRCAT(10),TPROG(25),TRLCAT(10)
      COMMON/DEPSPT/AVALD(10),DETA(10),DFIT,JSED,LCOMD(10),MINSED,
     1             MSEDO(10),SECOD(10),USECOD(10),UTILD(10)
      COMMON/DOCMGT/CPNP,CPP,NNPBD,NNPDD,NPBD,NPDD
      COMMON/GENDAT/CMILES,CPMI,MINB,MINBP,MINDP,MINJP,PMILES,SUF(3),
     1             XMINB
      COMMON/HOURS/BHOURS(25),CBHRS(25),CMHRS(25),DHOURS(25),DMHRS(25),
     1            PMHRS(25)
      COMMON/INSTAL/ICOS(25),INCOS,RICOS,TCOSI(25),INYEAR
      COMMON/LABOR/CPFC,FITT,FTS,MTRR,MTTR,NFC,NSCAT,OTSLR(6),PCON(3),
     1            PMMH(10),SDIF(6),SLR(6),TRT,TRTD,TRTP
      COMMON/LCOSTS/BLABOR(25),CBCOST(25),CMCOST(25),DLABOR(25),
     1             DMCOST(25),PMCOST(25)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1             TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/LRUDAT/BMC(20),COND(20),DMC(20),ISPR(20),ITWL(20),LCOML(20)
     1            ,LMKUP,LMTBF(20),LMTTR(20),LUCOS(20),NLRU,NSRU(20),
     2            RTLB(20),RTS(20),WT(20)
      COMMON/NAMES/NAMFAC,SNAME,UNAME
      COMMON/PARAM/BASEYR,DSCNT,NYRS,XDIS,XLRN,TDIS
      COMMON/PRSNNL/ BPERS(25),CBPER(25),CMPER(25),DMPER(25),DPERS(25),
     1             PMB,PMD,PMJ,PMPER(25),PRODB,PRODD,PRODJ,TCOSB,
     2             TCOSD,TCOSJ(6),TRB,TRD,TRJ(6)
      COMMON/SAVEIT/SACOS(25),SICOS(25),SNRCOS(25,9),SRLCOS(25,9),
     1             STLLCO(25),STNRCO(25),STRLCO(25)
      COMMON/SPRSTK/BSOB,BSOBL,BSOD,BSODL,OSB,OSBL,OSD,OSDL,ROP
      COMMON/SRUDAT/BMCS(20,20),CONDB(20,20),DMCS(20,20),ITWS(20,20),
     1             LCOMS(20,20),NOSRU(20,20),RTSB(20,20),SMKUP,
     2             SFITT(20,20),SMTBF(20,20),SMTTR(20,20),SUCOS(20,20),
     3             WTB(20,20),ISPRB(20,20)
      COMMON/STOCK/HOLD,IAMC,NNIC
```

```
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),
     1              NOKWHR,NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C    *DECLARE VARIABLES
C
      INTEGER BASEYR,GSYS,ITWL,ITWS,JSEB,JSED,LCOMB,LCOMD,LCOML,LCOMS
      INTEGER MINB,MINBP,MINDP,MINJP,MINSEB,MINSED,NBAS,NDEP,NDS,NLRU
      INTEGER NNGS,NNPBD,NNPDD,NNRL(3),NOB,NOD,NOSRU,NPBD,NPDD,NRGS,NPC
      INTEGER NRL,NSCAT,NSRU,NWS,NYRS,XMIL,XMINB,YEAR,YMIL
      INTEGER*4 NAMFAC(4),LABOR(3)
      REAL    ACOS,AFHR,AVALB,AVALD,BETA,BIT,BLR,BMC,BMCS,NNIC,NOKWHR
      REAL    BMT,BSOB,BSOBL,BSOD,BSODL,CLCC,COND,CONDB,CPNP,CPFC
      REAL    CPP,CPROG,DETA,DFHR,DLR,DMC,DMCS,DMT,DSCNT
      REAL    FBLRU,FITT,FOCB,FOCD,FTS,HOLD,IAMC,ICOS,INCOS
      REAL    KFAC,LDIST,LMKUP,LMTBF,LMTTR,LUCOS,MSEBO,MSEDO,MTRR,MTTR
      REAL    NRCOS,OSB,OSBL,OSD,OSDL,OTSLR,PCON,PMB,PMD,PMJ,PMMH,PQTY
      REAL    PRODB,PRODD,PRODJ,RICOS,RLCOS,ROP,RTLB,RTS,RTSB
      REAL    RTSS,SDIF,SECOB,SECOD,SHC,SLR,SMKUP,SMTBF,SMTTR,SSHC,SUCOS
      REAL    SUF,TCOSA,TCOSB,TCOSD,TCOSI,TCOSJ,TCOSL,TCOSN,TCOSR,TFOH
      REAL    TLLCOS,TNRCAT,TNRCOS,TPROG,TRB,TRD,TRJ,TRLCAT,TRLCOS,TRT
      REAL    TRTD,TRTP,UCOS,UMTBF,USECOB,USECOD,UTILB,UTILD,WT,WTB
      REAL    XDIS,XLRN
      LOGICAL*1 SFILE(16),SNAME(65),UNAME(35),TDIS,REPFAC(16)
      DATA SFILE/'S','Y','0',':',6*'X','.','D','A','T',0,0/
      DATA REPFAC/'S','Y','0',':',6*'X','.','D','A','T',0,0/
      DATA DSCNT/0.0/
C
C    *INITIALIZE TERMINAL INPUT VARIABLES
C
10    WRITE(1,*) '----MLS GROUND SYSTEM LIFE CYCLE COST EVALUATION----'
      WRITE(1,*) ' '
      WRITE(1,*) ' '
20    WRITE(1,*) 'ENTER SYSTEM FILE NAME'
      READ(1,1001) (SFILE(I), I = 5, 10)
      WRITE(1,*) ' '
30    WRITE(1,*) 'REPAIR FACILITY FILE NAME?'
      READ(1,1001) (REPFAC(I), I = 5, 10)
      WRITE(1,*) ' '
40    WRITE(1,*) 'DISCOUNT RATE?'
      READ(1,*) XDIS
      WRITE(1,*) ' '
      WRITE(1,*) 'NUMBER OF YEARS IN LIFE CYCLE?'
      READ(1,*) NYRS
      WRITE(1,*) ' '
      WRITE(1,*) 'BASE YEAR FOR DISCOUNTING PURPOSES? (E.G.1980)'
      READ(1,*) BASEYR
      WRITE(1,*) ' '
      WRITE(1,*) 'VALUE OF K FACTOR? (MTBF SENSITIVITY ANALYSIS)'
      WRITE(1,*) '(ENTER 1.0 IF YOU DO NOT WISH TO PERFORM THE'
      WRITE(1,*) 'SENSITIVITY ANALYSIS.)'
      READ(1,*) KFAC
```

```
      WRITE(1,*) '  '
      WRITE(1,*) 'DO YOU WISH TO PRINT THE LIFE CYCLE COSTS FOR EACH'
      WRITE(1,*) 'SYSTEM TYPE EVALUATED?'
      READ(1,1001) TDIS
      WRITE(1,*) '  '
C
C    *READ DATA FROM SYSTEM AND FACILITY FILES
C
      OPEN(UNIT=2,NAME=REPFAC,TYPE='OLD',READONLY,ERR=901)
      READ(2,1000) (UNAME(I), I = 1,35)
C
C    *READ USER DATA FILE
C
      DO 50 I = 1, NYRS
        READ(2,1004) YEAR(I),NBAS(I),NDEP(I)
50    CONTINUE
      READ(2,1006) BLR,BMT,DLR,DMT
      READ(2,1006) BSOB,BSOBL,BSOD,BSODL
      READ(2,1006) OSB,OSBL,OSD,OSDL,ROP
      READ(2,1006) DIST,LDIST,LMKUP,SDIST,SMKUP
      READ(2,1004) MINBP,MINDP,MINJP,MINB,XMINB
      READ(2,1006) PMB,PMD,PMJ
      READ(2,1006) PRODB,PRODD,PRODJ
      READ(2,1008) HOLD,IAMC,MINSEB,MINSED
      READ(2,1015) SHC,SSHC,XMIL,YMIL
      READ(2,1006) TCOSB,TCOSD,TRB,TRD
      READ(2,1006) TRT,TRTD,TRTP
      READ(2,1006) CMILES,PMILES,CPMI
      READ(2,1006) SUF(1),SUF(2),SUF(3)
      READ(2,1015) CPKWHR,XLRN
C
C    *LABOR SKILL LEVEL DATA
C
      READ(2,1004) NSL
      DO 60 I = 1, NSL
        READ(2,1005) (LABOR(J), J = 1, 3)
        READ(2,1006) SLR(I),OTSLR(I),SDIF(I),TCOSJ(I),TRJ(I)
60    CONTINUE
C
C    *GROUND SYSTEM RESTORATION LEVEL DATA
C
      DO 65 I = 1, 3
        READ(2,1016)
        READ(2,1014) NDS(I),NWS(I),PCON(I)
65    CONTINUE
C
C    *CLOSE USER DATA FILE AND OPEN SYSTEM DATA FILE
C
      CLOSE(UNIT=2,ERR=903)
      OPEN(UNIT=2,NAME=SFILE,TYPE='OLD',READONLY,ERR=901)
      READ(2,1000) (SNAME(I), I = 1,65)
```

```
C
C    *READ SYSTEM DATA FILE
C
      READ(2,1004) NFT
      DO 200 N = 1, NFT
C
C      *INITIALIZE SYSTEM VARIABLES TO ZERO
C
        DO 70 J = 1, 20
          LUCOS(J) = 0.0
          LMTBF(J) = 0.0
          WT(J) = 0.0
70      CONTINUE
        UMTBF = 0.0
        UCOS = 0.0
C
        DO 72 J = 1, NYRS
          DO 71 K = 1, 3
            NRL(J,K) = 0.0
71        CONTINUE
72      CONTINUE
C
        READ(2,1005) (NAMFAC(J    ,4)
        WRITE(1,1005) (NAMFAC(J,  =1,4)
        WRITE(1,*) '  '
        READ (2,1004) INYEAR, LOGYR
        DO 75 I = 1,NYRS
          READ(2,1004) NNGS(I),NRGS(I),(NNRL(J),J=1,3)
C
C        *DETERMINE NO. OF SITES IN YEAR I HAVING RESTORATION LEVEL J
C
          DO 74 K = I, NYRS
            DO 73 J = 1, 3
              NRL(K,J) = NRL(K,J) + NNRL(J)
73          CONTINUE
74        CONTINUE
75      CONTINUE
C
        READ(2,1009) AFHR,DFHR,AMCOS,PQTY
        READ(2,1017) INCOS,RICOS,NOKWHR
        READ(2,1006) BIT,FITT,FTS
        READ(2,1004) NLRU,NSCAT,JSEB,JSED
        READ(2,1006) MTRR,MTTR,RTSS,NNIC
        READ(2,1008) FOCB,FOCD
        READ(2,1006) (PMMH(J),J = 1,5)
        READ(2,1006) (PMMH(J), J = 6, 10)
        READ(2,1012) CPNP,CPP,NFC,CPFC
        READ(2,1004) NNPBD,NNPDD,NPBD,NPDD
C
C      *READ LRU AND SRU DATA
C
```

```
      DO 90 J = 1, NLRU
        READ(2,1016)
        READ(2,1018) BMC(J),DMC(J),COND(J)
        READ(2,1011) LMTTR(J),ITWL(J),LCOML(J),ISPR(J)
        READ(2,1010) NSRU(J),RTLB(J),RTS(J),WT(J)
        IF (NSRU(J) .EQ. 0) GO TO 85
        DO 80 K = 1, NSRU(J)
          READ(2,1016)
          READ(2,1013) BMCS(J,K),CONDB(J,K),DMCS(J,K)
          READ(2,1004) ITWS(J,K),LCOMS(J,K),NOSRU(J,K),ISPRB(J,K)
          READ(2,1019) RTSB(J,K),SMTBF(J,K),SMTTR(J,K)
          READ(2,1019) SFITT(J,K),SUCOS(J,K),WTB(J,K)
C
C        *DETERMINE LUCOS, LMTBF, AND WT
C
          LUCOS(J) = LUCOS(J) + NOSRU(J,K)*SUCOS(J,K)
          IF (SMTBF(J,K) .NE. 0)
     1      LMTBF(J) = LMTBF(J) + (NOSRU(J,K)/SMTBF(J,K))
          WT(J) = WT(J) + WTB(J,K)
C
C        *RECALCULATE SUCOS TO ACCOUNT FOR DISTRIBUTION COST
C
          SUCOS(J,K) = SUCOS(J,K)*(1 + SDIST)
          SMTBF(J,K) = SMTBF(J,K)/KFAC
          BMCS(J,K) = BMCS(J,K)*KFAC
          DMCS(J,K) = DMCS(J,K)*KFAC
80      CONTINUE
C
C       *RECALCULATE LUCOS TO ACCOUNT FOR DISTRIBUTION COST
C
85      LUCOS(J) = LUCOS(J)*(1 + LDIST)
        IF (LMTBF(J) .NE. 0.) LMTBF(J) = (1./LMTBF(J))/KFAC
        BMC(J) = BMC(J)*KFAC
        DMC(J) = DMC(J)*KFAC
90    CONTINUE
C
C     *READ SUPPORT EQUIPMENT DATA
C
      IF (JSEB .EQ. 0) GO TO 105
      DO 100 J = 1, JSEB
        READ(2,1012) AVALB(J),BETA(J),LCOMB(J),MSEBO(J)
        READ(2,1019) SECOB(J),USECOB(J),UTILB(J)
100   CONTINUE
C
105   IF (JSED .EQ. 0) GO TO 115
      DO 110 J = 1, JSED
        READ(2,1012) AVALD(J),DETA(J),LCOMD(J),MSEDO(J)
        READ(2,1019) SECOD(J),USECOD(J),UTILD(J)
110   CONTINUE
C
C     *CALCULATE SYSTEM COST AND MTBF
C
```

```
115      DO 130 I = 1, NLRU
           IF (LMTBF(I) .NE. 0.) UMTBF = UMTBF + (1./LMTBF(I))
           UCOS = UCOS + LUCOS(I)
130      CONTINUE
C
         UMTBF = (1./UMTBF)
C
C       *CALCULATE ACQUISITION AND INSTALLATION COSTS
C
         CALL ACQCOS
C
C       *CALCULATE LOGISTIC SUPPORT COST OF GROUND SYSTEM
C
         CALL LOGCOS
C
C       *CALCULATE TOTALS FOR LIFE CYCLE
C
         CALL OUTONE
         CALL OUTTWO
200    CONTINUE
C
       CALL OUTTHR
C
C     *CLOSE INPUT FILES
C
210    CLOSE(UNIT=2,ERR=904)
C
       GO TO 999
C
C     *ERROR STATEMENTS
C
901    WRITE(1,*) 'ERROR IN OPENING SFILE. PLEASE TRY AGAIN.'
       GO TO 20
C
902    WRITE(1,*) 'ERROR IN OPENING REFFAC. PLEASE TRY AGAIN.'
       CLOSE(UNIT=2,ERR=903)
       GO TO 30
C
903    WRITE(1,*) 'ERROR IN CLOSING SFILE. PROGRAM ABORTED.'
       GO TO 999
C
904    WRITE(1,*) 'ERROR IN CLOSING REFFAC. PROGRAM ABORTED.'
       GO TO 999
C
C     *FORMAT STATEMENTS
C
1000   FORMAT(20X,65A1)
1001   FORMAT(10A1)
1002   FORMAT(F4.2)
1003   FORMAT(I4)
1004   FORMAT(10X,5(I8,7X))
```

```
1005  FORMAT(10X,4A4)
1006  FORMAT(10X,5(F8.2,7X))
1008  FORMAT(10X,2(F8.2,7X),2(I8,7X))
1009  FORMAT(10X,2(F8.2,7X),F8.0,7X,F8.2)
1010  FORMAT(10X,I8,4(7X,F8.2))
1011  FORMAT(10X,F8.2,7X,3(I8,7X))
1012  FORMAT(10X,2(F8.2,7X),I8,7X,F8.2)
1013  FORMAT(10X,F8.2,7X,F8.3,2(7X,F8.2))
1014  FORMAT(10X,2(I8,7X),F8.2)
1015  FORMAT(10X,2(F8.3,7X),2(I8,7X))
1016  FORMAT(20X)
1017  FORMAT(10X,F8.0,2(7X,F8.0))
1018  FORMAT(10X,2(F8.2,7X),F8.3)
1019  FORMAT(10X,F8.2,7X,F8.0,7X,F8.2)
C
999   STOP
      END
```

```
C                              SUBROUTINE ACQCOS
C
C        THE ACQCOS MODULE DETERMINES THE ACQUISITION COST OF THE MLS
C        GROUND EQUIPMENT FOR EACH YEAR IN THE LIFE CYCLE. ACOS
C        REPRESENTS THE ACQUISITION COSTS INCURRED IN YEAR I; TCOSA REP-
C        RESENTS THE TOTAL ACQUISITION COSTS INCURRED PRIOR TO YEAR I.
C
      SUBROUTINE ACQCOS
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1               NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/INSTAL/ICOS(25),INCOS,RICOS,TCOSI(25),INYEAR
      COMMON/PARAM/BASEYR,DSCNT,NYRS,XDIS,XLRN,TDIS
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),
     1               NOKWHR,NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NDS,NNGS,NOB,NOD,NRGS,NRL,NWS,NYRS,YEAR
      INTEGER BASEYR
      REAL    ACOS,AFHR,AMCOS,BIT,DFHR,DIST,FBLRU,DSCNT,XDIS,XLRN
      REAL    FUCOS,ICOS,INCOS,LC,PQTY,RICOS,RTSS,TCOSA,TCOSI,TFOH
      REAL    TQTY,UCOS,UMTBF,NOKWHR
      LOGICAL*1 ANS,TDIS
      DATA ACOS/25*0.0/, ANS/'Y'/, TCOSA/25*0.0/
C
C
C     *INITIAL PRODUCTION COSTS ARE AMORTIZED OVER THE FIRST
C     *TWO YEARS OF PRODUCTION
C
      AMCOS = AMCOS/(2.0*PQTY)
      TQTY = 0.0
C
      DO 10 I = 1, NYRS
C
        FUCOS = UCOS
C
C      *COST IS GREATER IF AMORTIZING INITIAL PRODUCTION COSTS
C      *(START-UP COSTS ARE AMORTIZED OVER FIRST TWO YEARS OF
C      *PRODUCTION.)
C
        IF (I .LE. 2) FUCOS = UCOS + AMCOS
C
C      *IS THE LEARNING CURVE TO BE USED?
C
        IF (ANS .NE. 'Y') GO TO 5
        IF (I .NE. 1) GO TO 2
        WRITE(1,*) 'IS THE LEARNING CURVE FACTOR TO BE APPLIED?'
        READ(1,1001) ANS
```

```
      WRITE(1,*) '  '
      IF (ANS .NE. 'Y') GO TO 5
2     LC = (TQTY + PQTY/2.)**(ALOG(XLRN)/ALOG(2.0))
      TQTY = TQTY + PQTY
      FUCOS = FUCOS * LC
C
C    *ADJUST FUCOS TO REFLECT DEALER MARK-UP/-DOWN
C
5     FUCOS = FUCOS*(1 + DIST)
C
C    *DETERMINE NUMBER OF SYSTEMS TO BE INSTALLED
C    *IN YEAR I
C    *IF (RETROFIT PERIOD IS OVER) NRGS(I) = 0
C
      GSYS(I) = NNGS(I) + NRGS(I)
C
C    *CALCULATE COST ASSOCIATED WITH ACQUISITION OF AVIONICS UNITS IN
C    *YEAR I
C
      COST = GSYS(I)*FUCOS
C
C    *UPDATE ACQUISITION COSTS FOR YEAR I
C
      ACOS(I) = ACOS(I) + COST
C
C    *CALCULATE INSTALLATION COST FOR FLEET
C
      L = 0
      IF (INYEAR .LT. I) L = I - INYEAR
      NS = 0
      DO 7 K = 1, L
        NS = NS + GSYS(K)
7     CONTINUE
      IF (NS .EQ. 0) L = 0
      IF (L .GT. 0) CALL INSCOS(I,L)
C
8     CONTINUE
10    CONTINUE
1001  FORMAT(2A1)
C
      RETURN
      END
```

```
C                               SUBROUTINE INSCOS
C
C        THE INSCOS MODULE DETERMINES THE INSTALLATION COST OF THE
C        MLS GROUND EQUIPMENT FOR EACH YEAR IN THE LIFE CYCLE.
C        ICOS REPRESENTS THE INSTALLATION COSTS INCURRED IN YEAR I;
C        TCOSI REPRESENTS THE TOTAL INSTALLATION COSTS INCURRED PRIOR
C        TO YEAR I.
C
      SUBROUTINE INSCOS(I,L)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/INSTAL/ICOS(25), INCOS, RICOS, TCOSI(25), INYEAR
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,YEAR
      REAL    BIT,FBLRU,ICOS,INCOS,RICOS,RTSS,TCOSI,TFOH
      DATA ICOS/25*0.0/, TCOSI/25*0.0/
C
C     *CALCULATE INSTALLATION COST FOR YEAR I
C
      COST = (NRGS(L)*RICOS + NNGS(L)*INCOS)
C
C     *UPDATE INSTALLATION COSTS FOR YEAR I
C
      ICOS(I) = ICOS(I) + COST
      RETURN
      END
```

```
C                    SUBROUTINE LOGCOS
C
C       THE MODULE LOGCOS DETERMINES THE RECURRING AND NONRECURRING
C       LOGISTIC SUPPORT COSTS OF THE SPECIFIED AVIONICS EQUIPMENT
C       IN EACH OF EIGHT CATEGORIES: SPARES, ON-SITE MAINTENANCE,
C       OFF-SITE MAINTENANCE, INVENTORY ENTRY AND SUPPLY MANAGEMENT,
C       SPECIAL SUPPORT EQUIPMENT, PERSONNEL TRAINING, DATA MANAGE-
C       MENT AND TECHNICAL DOCUMENTATION, AND FACILITIES.
C
      SUBROUTINE LOGCOS
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1             NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/BASDEP/BLR,BMT,DLR,DMT,FOCB,FOCD,SHC,SSHC,XMIL,YMIL
      COMMON/BASSPT/AVALB(10),BETA(10),BFIT,JSEB,LCOMB(10),MINSEB,
     1             MSEBO(10),SECOB(10),USECOB(10),UTILB(10)
      COMMON/CAT/CLCC,CPROG(25),TNRCAT(10),TPROG(25),TRLCAT(10)
      COMMON/DEPSPT/AVALD(10),DETA(10),DFIT,JSED,LCOMD(10),MINSED,
     1             MSEDO(10),SECOD(10),USECOD(10),UTILD(10)
      COMMON/DOCMGT/CPNP,CPP,NNPBD,NNPDD,NPBD,NPDD
      COMMON/GENDAT/CMILES,CPMI,MINB,MINBP,MINDP,MINJP,PMILES,SUF(3),
     1             XMINB
      COMMON/HOURS/BHOURS(25),CBHRS(25),CMHRS(25),DHOURS(25),DMHRS(25),
     1            PMHRS(25)
      COMMON/LABOR/CPFC,FITT,FTS,MTRR,MTTR,NFC,NSCAT,OTSLR(6),PCON(3),
     1            PMMH(10),SDIF(6),SLR(6),TRT,TRTD,TRTP
      COMMON/LCOSTS/BLABOR(25),CBCOST(25),CMCOST(25),DLABOR(25),
     1             DMCOST(25),PMCOST(25)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1             TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/LRUDAT/BMC(20),COND(20),DMC(20),ISPR(20),ITWL(20),LCOML(20)
     1             ,LMKUP,LMTBF(20),LMTTR(20),LUCOS(20),NLRU,NSRU(20),
     2             RTLB(20),RTS(20),WT(20)
      COMMON/PARAM/BASEYR,DSCNT,NYRS,XDIS,XLRN,TDIS
      COMMON/PRSNNL/BPERS(25),CBPER(25),CMPER(25),DMPER(25),DPERS(25),
     1             PMB,PMD,PMJ,PMPER(25),PRODB,PRODD,PRODJ,TCOSB,
     2             TCOSD,TCOSJ(6),TRB,TRD,TRJ(6)
      COMMON/SPRSTK/BSOB,BSOBL,BSOD,BSODL,OSB,OSBL,OSD,OSDL,ROP
      COMMON/SRUDAT/BMCS(20,20),CONDB(20,20),DMCS(20,20),ITWS(20,20),
     1             LCOMS(20,20),NOSRU(20,20),RTSB(20,20),SMKUP,
     2             SFITT(20,20),SMTBF(20,20),SMTTR(20,20),SUCOS(20,20),
     3             WTB(20,20),ISPRB(20,20)
      COMMON/STOCK/HOLD,IAMC,NNIC
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),
     1             NOKWHR,NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,ITWL,ITWS,JSEB,JSED,LCOMB,LCOMD,LCOML,LCOMS,MINB
```

```
      INTEGER MINBP,MINDP,MINJP,MINSEB,MINSED,NBAS,NDEF,NDS
      INTEGER NLRU,NNGS,NNPBD,NNPDD,NOB,NOD,NPBD,NPDD,NRL,BASEYR
      INTEGER NRGS,NSCAT,NSRU,NWS,NYRS,XMIL,XMINB,YEAR,YMIL
      REAL    AFHR,AMCOS,AVALB,AVALD,BETA,BFIT,BIT,BLR,BMC,BMCS
      REAL    BMT,BSOB,BSOBL,BSOD,BSODL,CLCC,COND,CONDB,CPNP,CPP,CPROG
      REAL    DETA,DFHR,DFIT,DIST,DLR,DMC,DMCS,DMT,DSCNT,NNIC,NOKWHR
      REAL    FBLRU,FITT,FOCB,FOCD,FTS,HOLD,IAMC,LMKUP
      REAL    LMTBF,LMTTR,LUCOS,MSEBO,MSEDO,MTRR,MTTR,NRCOS,OSB
      REAL    OSBL,OSD,OSDL,OTSLR,PCON,PMB,PMD,PMJ,PMMH,PQTY,PRODB,PRODD
      REAL    PRODJ,RLCOS,RTLB,ROP,RTS,RTSB,RTSS,SDIF,SECOB
      REAL    SECOD,SHC,SLR,SMKUP,SMTBF,SMTTR,SSHC,SUCOS,SUF
      REAL    TCOSB,TCOSD,TCOSJ,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TNRCAT
      REAL    TNRCOS,TPROG,TRB,TRD,TRJ,TRLCAT,TRLCOS,TRT,TRTD,TRTP,UCOS
      REAL    UMTBF,USECOB,USECOD,UTILB,UTILD,WT,WTB,XDIS,XLRN
      LOGICAL*1 TDIS
      DATA TNRCOS/25*0.0/,TRLCOS/25*0.0/,TLLCOS/25*0.0/
      DATA NRCOS/225*0.0/,RLCOS/225*0.0/
C
C     *CALCULATE AVG. FAULT-ISOLATE AND TEST TIME AT BASE (BFIT) AND
C     *DEPOT (DFIT)
C
      NS = 0
      FBLRU = BIT + (1-BIT)*RTSS
C
      BFIT = 0.0
      DFIT = 0.0
      DO 20 K = 1, NLRU
        IF (NSRU(K) .EQ. 0) GO TO 20
        DO 10 L = 1, NSRU(K)
          IF (SMTBF(K,L) .EQ. 0.) GO TO 10
          BFIT = BFIT + (1-FTS)*FBLRU*RTS(K)*RTSB(K,L)*SFITT(K,L)
     1             *NOSRU(K,L)/SMTBF(K,L)
          DFIT = DFIT + (1-FTS)*((1-BIT)*(1-RTSS) + FBLRU*((1-RTS(K)) +
     1           RTS(K)*(1-RTSB(K,L))))*SFITT(K,L)*NOSRU(K,L)/SMTBF(K,L)
10      CONTINUE
20    CONTINUE
C
      DO 50 I = 1, NYRS
        NOB = NBAS(I)
        NOD = NDEF(I)
        L = 0
        IF (LOGYR .LT. I) L = I - LOGYR
        NSTEMP = 0
        DO 30 K = 1, L
          NSTEMP = NSTEMP + GSYS(K)
30      CONTINUE
        IF (NSTEMP .EQ. 0) L = 0
C
C       *CALCULATE NUMBER OF SYSTEMS OPERATING IN YEAR I
C
        NS = NS + GSYS(I)
C
C       *CALCULATE TOTAL EQUIPMENT OPERATING HOURS FOR SYSTEMS
C
```

```
      TFOH(I) = AFHR*NS
C
      IF (L .EQ. 0) GO TO 50
C
C     *CALCULATE COST OF INITIAL AND REPLACEMENT SPARES
C
      CALL SPARES(I,L,NYRS)
C
C     *CALCULATE COST OF ON-SITE MAINTENANCE
C
      CALL ONSITE(I,L,NYRS)
C
C     *CALCULATE COSTS OF OFF-SITE MAINTENANCE
C
      CALL OFSITE(I,L,NYRS)
C
C     *CALCULATE COSTS OF INVENTORY ENTRY AND SUPPLY MANAGEMENT
C
      CALL INVENT(I,NYRS)
C
C     *CALCULATE COSTS OF SPECIAL SUPPORT EQUIPMENT
C
      CALL SPTEQP(I,L,NYRS)
C
C     *CALCULATE COSTS OF TRAINING PERSONNEL
C
      CALL PERSON(I,L,NYRS)
C
C     *CALCULATE COSTS OF DATA MANAGEMENT AND TECHNICAL DOCUMENTATION
C
      CALL DATMGT(I,NYRS)
C
C     *CALCULATE COSTS OF OPERATING REPAIR FACILITIES
C
      CALL OPFAC(I)
C
C     *CALCULATE COST OF OPERATING SYSTEM SITES
C
      CALL SYSOP(I,L)
C
C     *TOTAL NONRECURRING AND RECURRING LOGISTICS COSTS FOR YEAR I
C
      DO 45 J = 1, 9
        TNRCOS(I) = TNRCOS(I) + NRCOS(I,J)
        TRLCOS(I) = TRLCOS(I) + RLCOS(I,J)
45    CONTINUE
C
C     *TOTAL LOGISTIC COSTS FOR YEAR I
C
      TLLCOS(I) = TNRCOS(I) + TRLCOS(I)
50    CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE SPARES(I,L,NYRS)
C
C        THE MODULE SPARES DETERMINES THE NUMBER OF SPARES OF EACH
C        TYPE THAT MUST BE STOCKED AT THE HUB (BASE) AND DEPOT LE-
C        VELS OF REPAIR IN ORDER TO SATISFY EXPECTED DEMAND.  NON-
C        RECURRING SPARES ARE THOSE SPARES PURCHASED TO MEET
C        EXPECTED DEMANDS DUE TO UNIT FAILURES; RECURRING SPARES
C        ARE THOSE PURCHSED TO REPLACE SPARES LOST TO ATTRITION OR
C        PILFERAGE.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/BASDEP/BLR,BMT,DLR,DMT,FOCB,FOCD,SHC,SSHC,XMIL,YMIL
      COMMON/GENDAT/CMILES,CPMI,MINB,MINBP,MINDP,MINJP,PMILES,SUF(3),
     1              XMINB
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/LRUDAT/BMC(20),COND(20),DMC(20),ISPR(20),ITWL(20),LCOML(20)
     1              ,LMKUP,LMTBF(20),LMTTR(20),LUCOS(20),NLRU,NSRU(20),
     2              RTLB(20),RTS(20),WT(20)
      COMMON/SPRSTK/BSOB,BSOBL,BSOD,BSODL,OSB,OSBL,OSD,OSDL,ROP
      COMMON/SRUDAT/BMCS(20,20),CONDB(20,20),DMCS(20,20),ITWS(20,20),
     1              LCOMS(20,20),NOSRU(20,20),RTSB(20,20),SMKUP,
     2              SFITT(20,20),SMTBF(20,20),SMTTR(20,20),SUCOS(20,20),
     3              WTB(20,20),ISPRB(20,20)
C
C     *DECLARE VARIABLES
C
      INTEGER BLRU,BSRU,DLRU,DSRU,GSYS,ITWL,ITWS,LCOML,LCOMS,MINB,MINBP
      INTEGER MINDP,MINJP,MINLRU,MINSRU,NBAS,NDEP,NLRU,NNGS
      INTEGER NOB,NOD,NOSRU,NRGS,NSRU,XMIL,XMINB,YEAR,YMIL
      REAL    BMT,BSOB,BSOBL,BSOD,BSODL,COND,CONDB,DMT,FBLRU,FOCB
      REAL    FOCD,JRTS,LMKUP,LMTBF,LMTTR,LUCOS,MTBFL,MTBFS,NSPRL(20)
      REAL    NSPRB(20,20),NRCOS,OSB,OSBL,OSD,OSDL,RLCOS,ROP,RTS,RTSB
      REAL    SMTBF,SMTTR,SUCOS,SUF,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TNRCOS
      REAL    TRLCOS,XRTSB,NLSPRS,NSSPRS,SMKUP,RLSPRS,RSSPRS
      DATA MFLAG/0/
C
C     *INITIALIZE VARIABLES
C
      MFLAG = MFLAG + 1
      IF (MFLAG .NE .1) GO TO 5
      DO 3 J = 1, NLRU
        NSPRL(J) = 0.0
        DO 2 K = 1, NSRU(J)
          NSPRB(J,K) = 0.0
2       CONTINUE
3     CONTINUE
C
```

```
5     DO 60 J = 1, NLRU
        MTBFL = LMTBF(J)
        IF (MTBFL .EQ. 0.) GO TO 60
        JRTS  = RTS(J)
C
C      *INVESTMENT LRUS (NONRECURRING)
C      *DETERMINE IF LRU IS REPAIRABLE OR NON-REPAIRABLE
C
        IF (ITWL(J) .EQ. 1) GO TO 10
C
C      *REPAIRABLE LRUS
C
        YDUM = TFOH(L)*(FBLRU*JRTS*BMT)/(NOB*MTBFL)
        ZDUM = TFOH(L)*(FBLRU*(1-JRTS)*DMT)/(NOD*MTBFL)
C
        BLRU = INT(NOB*(YDUM + SUF(2)*SQRT(YDUM)) + .999)
        MINLRU = MINB*NOB/LCOML(J)
        IF (BLRU .LT. MINLRU) BLRU = MINLRU
C
        DLRU = INT(NOD*(ZDUM + SUF(2)*SQRT(ZDUM)) + .999)
        MINLRU = MINB*NOD/LCOML(J)
        IF (DLRU .LT. MINLRU) DLRU = MINLRU
C
        NLSPRS = (BLRU + DLRU)*ISPR(J) - NSPRL(J)
        GO TO 20
C
C      *NON-REPAIRABLE LRUS
C
10      YDUM = TFOH(L)*FBLRU*BSOBL/(NOB*MTBFL)
        ZDUM = TFOH(L)*FBLRU*BSODL/(NOD*MTBFL)
        TDUM = TFOH(L)*FBLRU*OSBL/MTBFL
        SDUM = TFOH(L)*FBLRU*OSDL/MTBFL
        RDUM = TFOH(L)*ROP/MTBFL
        NLSPRS = (AINT(NOB*(YDUM + SUF(2)*SQRT(YDUM))+.999)
     1           + AINT(NOD*(ZDUM + SUF(2)*SQRT(ZDUM))+.999)
     2           + AINT(TDUM+.999) + AINT(SDUM+.999) + AINT(RDUM+.999)
     3           )*ISPR(J) - NSPRL(J)
20      IF (NLSPRS .LT. 0.) GO TO 25
        NSPRL(J) = NSPRL(J) + NLSPRS
        NRCOS(I,1) = NRCOS(I,1) + NLSPRS*LUCOS(J)
C
C      *REPLENISHMENT LRUS (RECURRING)
C
25      RLSPRS = AINT((TFOH(L)*COND(J)/MTBFL)+.999)
        RLCOS(I,1) = RLCOS(I,1) + RLSPRS*LUCOS(J)*(1 + LMKUP)
C
C      *SRU INITIAL AND REPLACEMENT SPARES
C
        IF (NSRU(J) .EQ. 0) GO TO 60
        DO 50 K = 1, NSRU(J)
          MTBFS = SMTBF(J,K)
```

```
          IF (MTBFS .EQ. 0.) GO TO 50
          XRTSB = RTSB(J,K)
C
C        *INVESTMENT SRUS (NONRECURRING)
C        *DETERMINE IF SRU(J,K) IS REPAIRABLE OR NON-REPAIRABLE
C
          IF (ITWS(J,K) .EQ. 1) GO TO 30
C
C        *REPAIRABLE SRUS
C
          XDUM = TFOH(L)*(FBLRU*JRTS*XRTSB*BMT)/(NOB*MTBFS)
          YDUM = TFOH(L)*(FBLRU*(JRTS*(1-XRTSB)+(1-JRTS))*DMT)/(NOD*
     +            MTBFS)
C
          BSRU = INT(NOB*(XDUM + SUF(3)*SQRT(XDUM))+.999)*NOSRU(J,K)
          MINSRU = (XMINB*NOB*NOSRU(J,K))/LCOMS(J,K)
          IF (BSRU .LT. MINSRU) BSRU = MINSRU
C
          DSRU = INT(NOD*(YDUM + SUF(3)*SQRT(YDUM))+.999)*NOSRU(J,K)
          MINSRU = (XMINB*NOD*NOSRU(J,K))/LCOMS(J,K)
          IF (DSRU .LT. MINSRU) DSRU = MINSRU
C
          NSSPRS = (BSRU + DSRU)*ISPRB(J,K) - NSPRB(J,K)
          GO TO 40
C
C        *NON-REPAIRABLE SRUS
C
30        XDUM = TFOH(L)*FBLRU*JRTS*BSOB/(NOB*MTBFS)
          YDUM = TFOH(L)*FBLRU*(1-JRTS)*BSOD/(NOD*MTBFS)
          WDUM = TFOH(L)*FBLRU*JRTS*OSB/MTBFS
          TDUM = TFOH(L)*FBLRU*(1-JRTS)*OSD/MTBFS
          SDUM = TFOH(L)*ROP/MTBFS
          NSSPRS = ((AINT(NOB*(XDUM + SUF(3)*SQRT(XDUM))+.999)
     1              + AINT(NOD*(YDUM + SUF(3)*SQRT(YDUM))+.999)
     2              +AINT(WDUM+.999)+AINT(TDUM+.999)+AINT(SDUM+.999))
     3              *NOSRU(J,K))*ISPRB(J,K) - NSPRB(J,K)
40        IF (NSSPRS .LT. 0.) GO TO 45
          NSPRB(J,K) = NSPRB(J,K) + NSSPRS
          NRCOS(I,1) = NRCOS(I,1) + NSSPRS*SUCOS(J,K)
C
C        *REPLENISHMENT SRUS (RECURRING)
C
45        RSSPRS = AINT((TFOH(L)*CONDB(J,K)*NOSRU(J,K)/MTBFS)+.999)
          RLCOS(I,1) = RLCOS(I,1) + RSSPRS*SUCOS(J,K)*(1+SMKUP)
50      CONTINUE
60    CONTINUE
      IF (I .EQ. NYRS) MFLAG = 0
      RETURN
      END
```

```
C                          SUBROUTINE ONSITE
C
C       THE MODULE ONSITE DETERMINES THE ANNUAL COST OF ON-SITE MAINTE-
C       NANCE FOR EACH OF THE INDEPENDENT MLS GROUND SYSTEM TYPES
C       THROUGHOUT THE LIFE CYCLE.  THE NONRECURRING PORTION OF THIS
C       COST ELEMENT IS ZERO; THE RECURRING COSTS INCLUDE THE COSTS OF
C       REMOVE AND REPLACE ACTIONS AND PREVENTIVE MAINTENANCE.
C
      SUBROUTINE ONSITE(I,L,NYRS)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),NNGS(25),
     1              NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/GENDAT/CMILES,CPMI,MINB,MINBP,MINDP,MINJP,PMILES,SUF(3),
     1              XMINB
      COMMON/HOURS/BHOURS(25),CBHRS(25),CMHRS(25),DHOURS(25),DMHRS(25),
     1             PMHRS(25)
      COMMON/LABOR/CPFC,FITT,FTS,MTRR,MTTR,NFC,NSCAT,OTSLR(6),PCON(3),
     1             PMMH(10),SDIF(6),SLR(6),TRT,TRTD,TRTP
      COMMON/LCOSTS/BLABOR(25),CBCOST(25),CMCOST(25),DLABOR(25),
     1              DMCOST(25),PMCOST(25)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/PRSNNL/BPERS(25),CBPER(25),CMPER(25),DMPER(25),DPERS(25),
     1              PMB,PMD,PMJ,PMPER(25),PRODB,PRODD,PRODJ,TCOSB,
     2              TCOSD,TCOSJ(6),TRB,TRD,TRJ(6)
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),
     1              NOKWHR,NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C     *DECLARE VARIABLES
C
      INTEGER FI(10),MES(3),MS(3),NC,NDS,NRL,NSCAT,NWS,GSYS,YEAR
      INTEGER XMINB,NFC
      REAL    AFHR,AMCOS,DFHR,DIST,RLF(3),CPFC
      REAL    FITT,FTS,MTRR,MTTR,NRCOS,OTSLR,PCON,PD(3),PE(3),PMMH
      REAL    PQTY,RLCOS,RSF(3),SDIF,SHFT,SLR,SMMHC,SMMHP,TCOSL
      REAL    TCOSN,TCOSR,TLLCOS,TNRCOS,TRLCOS,TRT,TRTD,TRTP,UCOS,UMTBF
      REAL    XNOFD,XNOFW,NOKWHR
      DATA MFLAG/0/
C
C     *NONRECURRING COSTS
C
C      NRCOS(I,2) = 0.0
C
C     *RECURRING COSTS
C
C     *COST OF CORRECTIVE MAINTENANCE
C
C     *INITIALIZE MAINTENANCE VARIABLES TO ZERO
C
```

```
      MFLAG = MFLAG + 1
      IF (MFLAG .NE. 1) GO TO 7
      DO 5 J = 1, NYRS
        CMHRS(J) = 0.0
        PMHRS(J) = 0.0
        CBHRS(J) = 0.0
        DMHRS(J) = 0.0
        BHOURS(J) = 0.0
        DHOURS(J) = 0.0
        BLABOR(J) = 0.0
        CBCOST(J) = 0.0
        CMCOST(J) = 0.0
        DLABOR(J) = 0.0
        DMCOST(J) = 0.0
        PMCOST(J) = 0.0
        BPERS(J)  = 0.0
        CBPER(J)  = 0.0
        CMPER(J)  = 0.0
        DMPER(J)  = 0.0
        DPERS(J)  = 0.0
        PMPER(J)  = 0.0
5     CONTINUE
C
7     PTRAV = 0.0
      CTRAV = 0.0
C    *AVERAGE NUMBER OF FAILURES PER YEAR
C
      XNOF = AFHR/UMTBF
C
C    *AVERAGE NUMBER OF WEEKDAY FAILURES
C
      XNOFD = 260*DFHR/UMTBF
C
C    *AVERAGE NUMBER OF WEEKEND FAILURES
C
      XNOFW = XNOF - XNOFD
C
C    *AVERAGE (DAILY) WEEKEND OPERATING HOURS PER SYSTEM
C
      EOH = AFHR/104 - 2.5*DFHR
C
C    *INITIALIZE MAINTENANCE SHIFT IDENTIFIERS
C
      DO 10 J = 1, 3
        MS(J) = 1
        MES(J) = 1
        PD(J) = 0.
        PE(J) = 0.
10    CONTINUE
C
C    *DETERMINE DAILY AND WEEKEND FAILURE ALLOCATION FACTORS
C
```

```
      IF (DFHR .LE. 16.) GO TO 20
      PD(1) = .333
      PD(2) = .333
      PD(3) = .333
20    IF (DFHR .LE. 8.) PD(1) = 1.
      IF ((DFHR .LE. 8.) .OR. (DFHR .GE. 16.)) GO TO 30
      PD(1) = .5
      PD(2) = .5
30    IF ((EOH .GT. 0.) .AND. (EOH .LT. 8.)) PE(1) = 1.
      IF (EOH .LE. 16.) GO TO 40
      PE(1) = .333
      PE(2) = .333
      PE(3) = .333
40    IF ((EOH .LE. 8.) .OR. (EOH .GT. 16.)) GO TO 50
      PE(1) = .5
      PE(2) = .5
50    CONTINUE
C
C    *SET PREVENTIVE MAINTENANCE FREQUENCY IDENTIFIERS
C
      DO 60 J = 1, 10
        FI(J) = 0
        IF (PMMH(J) .NE. 0) FI(J) = 1
60    CONTINUE
C
C    *DETERMINE DAILY AND WEEKEND SHIFT IDENTIFIERS
C
      DO 80 J = 1, 3
        RSF(J) = 0.
        IF (NDS(J) .LE. 2) MS(3) = 0
        IF (NDS(J) .EQ. 1) MS(2) = 0
        IF (NWS(J) .LE. 2) MES(3) = 0
        IF (NWS(J) .LE. 1) MES(2) = 0
        IF (NWS(J) .EQ. 0) MES(1) = 0
C
C      *DETERMINE REGULAR SHIFT MAINTENANCE DEMANDS
C
        DO 70 K = 1, 3
          RSF(J)=RSF(J)+NRL(L,J)*(PD(K)*XNOFD*MS(K)+PE(K)*XNOFW*MES(K))
          MS(K) = 1
          MES(K) = 1
70      CONTINUE
C
C      *NON-REGULAR SHIFT MAINTENANCE DEMANDS
C
        RLF(J) = XNOF*NRL(L,J) - RSF(J)
80    CONTINUE
C
C    *TOTAL CORRECTIVE MAINTENANCE (CM) LABOR HOURS PER ACTION
C
      SMMHC = 2*TRT + FITT + FTS*MTTR + (1-FTS)*MTRR
C
```

```
      DO 90 J = 1, 3
C
        SHFT = 1.
        IF (J .EQ. 3) SHFT = SDIF(NSCAT)
C
C      *CM DEMAND (HOURS) PER RESTORATION LEVEL
C
        CMDEM = (RSF(J) + RLF(J)*(1-PCON(J)))*SMMHC*SHFT
C
C      *DETERMINE NUMBER OF SHIFTS PER WEEK FOR RESTORATION LEVEL J
C
        NSHFT = 5*NDS(J) + 2*NWS(J)
        IF (CMDEM .EQ. 0) NSHFT = 1
C
C      *INCLUDE PERSONNEL SUFFICIENCY FACTOR IN DETERMINING REQUIRED
C      *NUMBER OF REPAIR PERSONNEL
C
        XDUM = CMDEM/NSHFT + SUF(1)*SQRT(CMDEM/NSHFT)
        CMHRS(I) = CMHRS(I) + NSHFT*XDUM
C
        NC = 0
        IF (NWS(J) .NE. 0) NC = 1
C
C      *PM DEMAND (HOURS) PER RESTORATION LEVEL PER FACILITY TYPE
C
        PMHRS(I)=PMHRS(I)+NRL(L,J)*((260+104*NC)*(2*TRTD+PMMH(1))*FI(1)
     1          + 52*(2*TRT+PMMH(2))*FI(2) + 12*(2*TRT+PMMH(3))*FI(3)
     2          + 4*(2*TRT+PMMH(4))*FI(4) + 2*(2*TRT+PMMH(5))*FI(5)
     3          + (2*TRT+PMMH(6))*FI(6) + (780+312*NC)*(2*TRTD+PMMH(7))*
     4          FI(7) + (130+52*NC)*(2*TRT+PMMH(8))*FI(8) + 104*(2*TRT+
     5          PMMH(9))*FI(9) + 26*(2*TRT+PMMH(10))*FI(10))*SHFT
C
C      *CALCULATE COST OF TRAVEL TO SITE FOR PM
C
        PTRAV = PTRAV + 2*NRL(L,J)*((260+104*NC)*FI(1)+52*FI(2)+12*FI(3)
     1           + 4*FI(4) + 2*FI(5) + FI(6) + (780+312*NC)*FI(7)
     2           + (130+52*NC)*FI(8) + 104*FI(9) + 26*FI(10))*PMILES*CPMI
C
90    CONTINUE
C
C     *TOTAL CALL-BACK LABOR HOURS PER ACTION PER FACILITY TYPE
C
      SMMHP = 2*TRTP + FITT + FTS*MTTR + (1-FTS)*MTRR
      IF (SMMHP .LT. 2.) SMMHP = 2.
      CBHRS(I) = RLF(2)*PCON(2)*SMMHP
      DMHRS(I) = DMHRS(I) + CMHRS(I) + PMHRS(I) + CBHRS(I)
C
C     *CALCULATE NO. OF TECHNICIANS REQUIRED FOR CM, PM, AND CALL-BACKS
C
      CMPER(I) = (CMHRS(I)/(PMJ*PRODJ))*MINJP
      PMPER(I) = (PMHRS(I)/(PMJ*PRODJ))*MINJP
      CBPER(I) = (CBHRS(I)/(PMJ*PRODJ))
```

```
      DMPER(I) = CHPER(I) + PMPER(I) + CBPER(I)
C
C    *CALCULATE COST OF TECHNICIANS (PMCOST INCLUDES FLIGHT CHECKS)
C
      CMCOST(I) = CMHRS(I)*SLR(NSCAT)/PMJ
      PMCOST(I) = PMHRS(I)*SLR(NSCAT)/PMJ + NFC*CPFC
      CBCOST(I) = CBHRS(I)*OTSLR(NSCAT)/PMJ
      DMCOST(I) = CMCOST(I) + PMCOST(I) + CBCOST(I)
C
C    *CALCULATE COST OF TRAVEL TO SITE FOR CM
C
      CTRAV = TFOH(L)*CMILES*CPMI/UMTBF
C
C    *TOTAL RECURRING ON-SITE MAINTENANCE COSTS
C
      RLCOS(I,2) = RLCOS(I,2) + DMCOST(I) + CTRAV + PTRAV
C
      IF (I .EQ. NYRS) MFLAG = 0
      RETURN
      END
```

```
      SUBROUTINE OFSITE(I,L,NYRS)
C
C        THE MODULE OFSITE DETERMINES THE COSTS OF OFF-SITE MAINTENANCE
C        AND INCLUDES THE RECURRING COSTS OF MATERIALS, LABOR, AND SHIP-
C        PING INCURRED IN THE REPAIR OF FAILED UNITS.  THE NONRECURRING
C        PORTION OF THIS COST ELEMENT IS NON-EXISTENT, I.E. NRCOS(I,3)
C        = 0.
C
C     *ESTABLISH C_MMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/BASDEP/BLR,BMT,DLR,DMT,FOCB,FOCD,SHC,SSHC,XMIL,YMIL
      COMMON/HOURS/BHOURS(25),CBHRS(25),CMHRS(25),DHOURS(25),DMHRS(25),
     1             PMHRS(25)
      COMMON/LCOSTS/BLABOR(25),CBCOST(25),CMCOST(25),DLABOR(25),
     1              DMCOST(25),PMCOST(25)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LCGYR
      COMMON/LRUDAT/BMC(20),COND(20),DMC(20),ISPR(20),ITWL(20),LCOML(20)
     1              ,LMKUP,LMTBF(20),LMTTR(20),LUCOS(20),NLRU,NSRU(20),
     2              RTLB(20),RTS(20),WT(20)
      COMMON/PRSNNL/BPERS(25),CBPER(25),CMPER(25),DMPER(25),DPERS(25),
     1              PMB,PMD,PMJ,PMPER(25),PRODB,PRODD,PRODJ,TCOSB,
     2              TCOSD,TCOSJ(6),TRB,TRD,TRJ(6)
      COMMON/SRUDAT/BMCS(20,20),CONDB(20,20),DMCS(20,20),ITWS(20,20),
     1              LCOMS(20,20),NOSRU(20,20),RTSB(20,20),SMKUP,
     2              SFITT(20,20),SMTBF(20,20),SMTTR(20,20),SUCOS(20,20),
     3              WTB(20,20),ISPRB(20,20)
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,ITWL,ITWS,LCOML,LCOMS,NBAS,NDEP,NLRU,NNGS,NOB,NOD
      INTEGER NOSRU,NRGS,NSRU,XMIL,YEAR,YMIL
      REAL    BLR,BMC,BMCS,BMT,COND,CONDB,DLR,DMC,DMCS,DMT,FBLRU,FOCB
      REAL    FOCD,JRTS,LMKUP,LMTBF,LMTTR,LUCOS,MTBFL,MTBFS
      REAL    NRCOS,RLCOS,RTLB,RTS,RTSB,SHC,SMKUP,SMTBF,SMTTR,SSHC
      REAL    SUCOS,TCOSL,TCOSN,TCOSR,TFOH,TLABOR,TLLCOS,TMAT,TNRCOS
      REAL    TRLCOS,TSHIP,WT,WTB,XLMAT,XBLREP,XDLREP,XLSHP,XLTTR,XRTSB
      REAL    XSMAT,XBSREP,XDSREP,XSSHP,XSTTR
      DATA MFLAG/0/
C
      MFLAG = MFLAG + 1
C
C     *NONRECURRING COSTS
C
      IF (MFLAG .NE. 1) GO TO 7
C
C     *CALCULATE UNIT WEIGHT
C
      SYSWT = 0.0
```

```
      DO 5 K = 1, NLRU
        SYSWT = SYSWT + WT(K)
5     CONTINUE
7     NRCOS(I,3) = NRCOS(I,3) + SYSWT*GSYS(L)*(YMIL*SSHC + XMIL*SHC)
C
C    *RECURRING COSTS
C
C    *INITIALIZE DUMMY VARIABLES TO ZERO
C
      XLMAT = 0.0
      XSMAT = 0.0
      XBLREP = 0.0
      XDLREP = 0.0
      XBSREP = 0.0
      XDSREP = 0.0
      XLSHP = 0.0
      XSSHP = 0.0
      XLTTR = 0.0
      XSTTR = 0.0
C
C    *CALCULATE COSTS FOR LRU LEVEL OF MAINTENANCE
C
      DO 20 J = 1, NLRU
        JRTS = RTS(J)
        MTBFL = LMTBF(J)
        IF (MTBFL .EQ. 0.) GO TO 20
C
C      *MATERIALS--LRU(J)
C
        XLMAT = XLMAT + FBLRU*(JRTS*RTLB(J)*BMC(J) + (JRTS*(1-RTLB(J)) +
     1          (1-JRTS))*DMC(J))/MTBFL
C
C      *LABOR--LRU(J)
C
        XBLREP = XBLREP + FBLRU*JRTS*LMTTR(J)*RTLB(J)*(1-ITWL(J))/MTBFL
        XDLREP = XDLREP + FBLRU*JRTS*LMTTR(J)*(1-RTLB(J))*(1-ITWL(J))
     +          /MTBFL
C
C      *SHIPPING--LRU(J)
C
        XLSHP = XLSHP + (WT(J)*(FBLRU*((1-JRTS) + JRTS*(1-RTLB(J)))*2
     1          *YMIL*SSHC*(1-ITWL(J)) + (FBLRU*(1-JRTS)*(YMIL*SSHC +
     2          XMIL*SHC)*ITWL(J)))/MTBFL)
C
C      *WEIGHT OF EQUIPMENT SHIPPED TO REPLACE CONDEMNED LRU(J)S
C
        XLTTR = XLTTR + WT(J)*COND(J)/MTBFL
C
C      *CALCULATE COSTS FOR SRU LEVEL OF MAINTENANCE
C
        IF (NSRU(J) .EQ. 0) GO TO 20
```

```
          DO 10 K = 1, NSRU(J)
            XRTSB = RTSB(J,K)
            MTBFS = SMTBF(J,K)
            IF (MTBFS .EQ. 0.) GO TO 10
C
C         *MATERIALS--SRU(J,K)
C
            XSMAT = XSMAT + NOSRU(J,K)*FBLRU*(JRTS*XRTSB*BMCS(J,K) +
     1              (JRTS*(1-XRTSB) + (1-JRTS))*DMCS(J,K))/MTBFS
C
C         *LABOR--SRU(J,K)
C
            XBSREP = XBSREP + NOSRU(J,K)*FBLRU*JRTS*XRTSB*SMTTR(J,K)
     +              *(1-ITWS(J,K))/MTBFS
            XDSREP = XDSREP + NOSRU(J,K)*FBLRU*(JRTS*(1-XRTSB)+(1-JRTS))
     +              *SMTTR(J,K)*(1-ITWS(J,K))/MTBFS
C
C         *SHIPPING--SRU(J,K)
C
            XSSHP = XSSHP + NOSRU(J,K)*(WTB(J,K)*((FBLRU*JRTS*(1-XRTSB)*2*
     1              YMIL*SSHC*(1-ITWS(J,K))) + (FBLRU*JRTS*(YMIL*SSHC +
     2              XMIL*SHC)*ITWS(J,K)))/MTBFS)
C
C         *WEIGHT OF EQUIPMENT SHIPPED TO REPLACE CONDEMNED SRU(J,K)S
C
            XSTTR=XSTTR+NOSRU(J,K)*WTB(J,K)*CONDB(J,K)/MTBFS
10        CONTINUE
20      CONTINUE
C
C     *MAKE FINAL CALCULATIONS IN EACH SUB-CATEGORY
C
C     *COST OF MATERIALS
C
        TMAT = TFOH(L)*(XLMAT + XSMAT)
C
C     *COST OF LABOR
C
        BHOURS(I) = TFOH(L)*(XBLREP + XBSREP)
        DHOURS(I) = TFOH(L)*(XDLREP + XDSREP)
        BPERS(I) = BHOURS(I)/(PMB*PRODB)
        DPERS(I) = DHOURS(I)/(PMD*PRODD)
        BLABOR(I) = BPERS(I)*PRODB*BLR
        DLABOR(I) = DPERS(I)*PRODD*DLR
        TLABOR = BLABOR(I) + DLABOR(I)
C
C     *COST OF SHIPPING
C
        TSHIP = PACK*TFOH(L)*((XLTTR + XSTTR)*(YMIL*SSHC + XMIL*SHC)
     1          + (XLSHP + XSSHP))
C
C     *TOTAL OFF-SITE MAINTENANCE RECURRING EXPENSE
C
        RLCOS(I,3) = RLCOS(I,3) + TMAT + TLABOR + TSHIP
C
        IF (I .EQ. NYRS) MFLAG = 0
        RETURN
        END
```

```
      SUBROUTINE INVENT(I,NYRS)
C
C       THE INVENT MODULE DETERMINES THE NONRECURRING COSTS OF FIRST-
C       TIME INVENTORY ENTRY AND THE RECURRING COSTS OF MAINTAINING
C       THAT INVENTORY.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/STOCK/HOLD,IAMC,NNIC
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,NYRS,MFLAG,YEAR
      REAL    BIT,FBLRU,HOLD,IAMC,NRCOS,RLCOS,NNIC
      REAL    TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TNRCOS,TRLCOS
      DATA MFLAG/0/
C
C     *NONRECURRING COSTS
C
      MFLAG = MFLAG + 1
      IF (MFLAG .NE. 1) GO TO 10
      NRCOS(I,4) = NRCOS(I,4) + IAMC*NNIC
C
C     *RECURRING COSTS
C
10    RLCOS(I,4) = RLCOS(I,4) + NNIC*HOLD
      IF (I .EQ. NYRS) MFLAG = 0
      RETURN
      END
```

```
      SUBROUTINE SPTEQP(I,L,NYRS)
C
C        THE SPTEQP MODULE DETERMINES THE NONRECURRING COST OF ACQUIRING
C        HUB (BASE) AND DEPOT SUPPORT EQUIPMENT SETS IN SUFFICIENT NUM-
C        BERS TO SATISFY EXPECTED DEMANDS AND THE RECURRING COSTS OF
C        OPERATING THOSE EQUIPMENT SETS.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/BASSPT/AVALB(10),BETA(10),BFIT,JSEB,LCOMB(10),MINSEB,
     1              MSEBO(10),SECOB(10),USECOB(10),UTILB(10)
      COMMON/DEPSPT/AVALD(10),DETA(10),DFIT,JSED,LCOMD(10),MINSED,
     1              MSEDO(10),SECOD(10),USECOD(10),UTILD(10)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),
     1              NOKWHR,NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,JSEB,JSED,LCOMB,LCOMD,MINSEB,MINSED,NDS
      INTEGER NNGS,NOB,NOD,NRL,NRGS,NSEB(10),NSED(10),NWS,XNSEB
      INTEGER XNSED,YEAR,YNSEB,YNSED
      REAL    AFHR,AMCOS,AVALB,AVALD,BETA,BFIT,DETA,DFHR,DFIT
      REAL    DIST,FBLRU,MSEBO,MSEDO,NNSEB,NNSED
      REAL    NRCOS,PQTY,RLCOS,RNSEB,RNSED,SECOB,SECOD,TCOSL
      REAL    TCOSN,TCOSR,TFOH,TLLCOS,TNRCOS,TRLCOS,UCOS,UMTBF,UTILB
      REAL    UTILD,USECOB,USECOD,XRSEB,XRSED,YRSEB,YRSED,NOKWHR
      DATA MFLAG/0/
C
C     *INITIALIZE VARIABLES
C
      NNSEB = 0.
      NNSED = 0.
      RNSEB = 0.
      RNSED = 0.
      MFLAG = MFLAG + 1
      IF (MFLAG .NE. 1) GO TO 5
      IF (JSEB .EQ. 0) GO TO 3
      DO 2 J = 1, JSEB
        NSEB(J) = 0
2     CONTINUE
3     IF (JSED .EQ. 0) GO TO 5
      DO 4 J = 1, JSED
        NSED(J) = 0
4     CONTINUE
C
C     *BASE SUPPORT EQUIPMENT
C
```

```
5      IF (JSEB .EQ. 0) GO TO 12
       DO 10 J = 1, JSEB
C
C       *NONRECURRING COSTS
C
         XNSEB = INT(TFOH(L)*BFIT*UTILB(J)/(UMTBF*AVALB(J)*BETA(J)))
         YNSEB = MINSEB*NOB/LCOMB(J)
         IF (XNSEB .LT. YNSEB) XNSEB = YNSEB
         NEWSPT = XNSEB - NSEB(J)
         IF (NEWSPT .LT. 0) GO TO 7
         NNSEB = NNSEB + NEWSPT*USECOB(J)
         NSEB(J) = NSEB(J) + NEWSPT
C
C       *RECURRING COSTS
C
7        XRSEB = TFOH(L)*BFIT*UTILB(J)*SECOB(J)/(UMTBF*AVALB(J)*BETA(J))
         YRSEB = MSEBO(J)*NSEB(J)
         IF (XRSEB .LT. YRSEB) XRSEB = YRSEB
         RNSEB = RNSEB + XRSEB
10     CONTINUE
C
C     *DEPOT SUPPORT EQUIPMENT
C
12     IF (JSED .EQ. 0) GO TO 25
       DO 20 J = 1, JSED
C
C       *NONRECURRING COSTS
C
         XNSED = INT(TFOH(L)*DFIT*UTILD(J)/(UMTBF*AVALD(J)*DETA(J)))
         YNSED = MINSED*NOD/LCOMD(J)
         IF (XNSED .LT. YNSED) XNSED = YNSED
         NEWSPT = XNSED - NSED(J)
         IF (NEWSPT .LT. 0) GO TO 15
         NNSED = NNSED + NEWSPT*USECOD(J)
         NSED(J) = NSED(J) + NEWSPT
C
C       *RECURRING COSTS
C
15       XRSED = TFOH(L)*DFIT*UTILD(J)*SECOD(J)/(UMTBF*AVALD(J)*DETA(J))
         YRSED = MSEDO(J)*NSED(J)
         IF (XRSED .LT. YRSED) XRSED = YRSED
         RNSED = RNSED + XRSED
20     CONTINUE
C
C     *TOTAL NONRECURRING COST, SPECIAL SUPPORT EQUIPMENT
C
25     NRCOS(I,5) = NRCOS(I,5) + NNSEB + NNSED
C
C     *TOTAL RECURRING COST, SPECIAL SUPPORT EQUIPMENT
C
       RLCOS(I,5) = RLCOS(I,5) + RNSEB + RNSED
C
       IF ( I .EQ. NYRS) MFLAG = 0
       RETURN
       END
```

```
      SUBROUTINE PERSON(I,L,NYRS)
C
C        THE MODULE PERSON DETERMINES THE NUMBER OF NEW REPAIR PERSONNEL
C        REQUIRED TO MEET EXPECTED REPAIR DEMANDS, THE NONRECURRING
C        COST OF INITIAL TRAINING AND THE RECURRING COST OF TRAINING
C        PERSONNEL TO REPLACE THOSE LOST TO PERSONNEL TURNOVER.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/GENDAT/CMILES,CPMI,MINB,MINBP,MINDP,MINJP,PMILES,SUF(3),
     1              XMINB
      COMMON/LABOR/CPFC,FITT,FTS,MTRR,MTTR,NFC,NSCAT,OTSLR(6),PCON(3),
     1             PMMH(10),SDIF(6),SLR(6),TRT,TRTD,TRTP
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/PRSNNL/BPERS(25),CBPER(25),CMPER(25),DMPER(25),DPERS(25),
     1              PMB,PMD,PMJ,PMPER(25),PRODB,PRODD,PRODJ,TCOSB,
     2              TCOSD,TCOSJ(6),TRB,TRD,TRJ(6)
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,MINB,MINBP,MINDP,MINJP,NBAS,NDEP,NNGS,NOB,NOD
      INTEGER NRGS,XMINB,YEAR,NBPER,NDPER,NJPER,NPERB,NPERD,NPERJ
      INTEGER BASEP,DEPOTP,DMPERS
      REAL    NRCOS,PMB,PMD,PMJ,MTRR,MTTR
      REAL    PRODB,PRODD,PRODJ,RLCOS,RTSS,SUF,TCOSB,TCOSD,TCOSJ,TCOSL
      REAL    TCOSN,TCOSR,TFOH,TLLCOS,TNRCOS,TRB,TRD,TRJ,TRLCOS
      DATA MFLAG/0/
C
C     *INITIALIZE VARIABLES
C
      MFLAG = MFLAG + 1
      IF (MFLAG .NE. 1) GO TO 10
      NPERJ = 0
      NPERB = 0
      NPERD = 0
C
10    NJPER = 0
      NBPER = 0
      NDPER = 0
C
C     *NONRECURRING COSTS (INITIAL TRAINING)
C
C     *JOURNEYING REPAIR PERSONNEL
C
      DMPERS = INT(DMPER(I) + .999)
      IF (DMPERS .LT. NPERJ) GO TO 20
      NJPER = DMPERS - NPERJ
      NPERJ = DMPERS
```

```
C
C     *BASE REPAIR PERSONNEL
C
20     BASEP = INT(BPERS(I) + .999)
       IF (BASEP .LT. NPERB) GO TO 30
       NBPER = BASEP - NPERB
       NPERB = BASEP
C
C     *DEPOT REPAIR PERSONNEL
C
30     DEPOTP = INT(DPERS(I) + .999)
       IF (DEPOTP .LT. NPERD) GO TO 40
       NDPER = DEPOTP - NPERD
       NPERD = DEPOTP
C
C     *TOTAL NONRECURRING
C
40     NRCOS(I,6) = NRCOS(I,6) + NJPER*TCOSJ(NSCAT) +
      +              NBPER*TCOSB + NDPER*TCOSD
C
C     *RECURRING COST (DUE TO PERSONNEL TURNOVER)
C
       RLCOS(I,6) = RLCOS(I,6) + NPERJ*TCOSJ(NSCAT)*TRJ(NSCAT)
      +              + NPERB*TCOSB*TRB + NPERD*TCOSD*TRD
C
       IF (I .EQ. NYRS) MFLAG = 0
       RETURN
       END
```

```
      SUBROUTINE DATMGT(I,NYRS)
C
C        THE DATMGT MODULE DETERMINES THE COST OF DATA MANAGEMENT.  THE
C        NONRECURRING COSTS CONSIST OF THE COST OF SUPPLYING EACH OF THE
C        BASES AND DEPOTS WITH THE REQUIRED EQUIPMENT AND REPAIR MANUALS;
C        THE RECURRING COSTS CONSIST OF THE COSTS OF KEEPING THOSE MANU-
C        UALS UP-TO-DATE.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/DOCMGT/CPNP,CPP,NNPBD,NNPDD,NPBD,NPDD
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNBAS,NNGS,NNDEP,NNPBD,NNPDD,NOB,NOD
      INTEGER NPBD,NPDD,NRGS,YEAR
      REAL    BIT,CPNP,CPP,FBLRU,NRCOS,RLCOS,TCOSL,TCOSN,TCOSR
      REAL    TFOH,TLLCOS,TNRCOS,TRLCOS
      DATA MFLAG/0/
C
C     *NONRECURRING COSTS
C
      MFLAG = MFLAG + 1
      IF (MFLAG .NE. 1) GO TO 10
      NNBAS = NOB
      NNDEP = NOD
      GO TO 20
10    NNBAS = NOB - NBAS(I-1)
      NNDEP = NOD - NDEP(I-1)
20    XDUM = FLOAT(NPBD)*FLOAT(NNBAS)
      YDUM = FLOAT(NPDD)*FLOAT(NNDEP)
      NRCOS(I,7) = NRCOS(I,7) + CPP*(XDUM + YDUM)
C
C     *RECURRING COSTS
C
      RLCOS(I,7) = RLCOS(I,7) + CPNP*(NNPBD*NOB + NNPDD*NOD)
C
      IF (I .EQ. NYRS) MFLAG = 0
      RETURN
      END
```

```
      SUBROUTINE OPFAC(I)
C
C        THE MODULE OPFAC DETERMINES THE COST OF OPERATING THE REPAIR
C        FACILITIES AT THE BASE AND DEPOT REPAIR LEVELS.  IT IS ASSUMED
C        THAT NO NEW REPAIR FACILITIES WILL BE CONSTRUCTED, MAKING THE
C        NONRECURRING COST ZERO.  THE RECURRING COST IS THE COST OF
C        FACILITY OPERATION WHICH IS ATTRIBUTABLE TO MAINTAINING THE MLS
C        GROUND SYSTEMS.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/BASDEP/BLR,BMT,DLR,DMT,FOCB,FOCD,SHC,SSHC,XMIL,YMIL
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,XMIL,YEAR,YMIL
      REAL    BIT,BLR,BMT,DLR,DMT,FBLRU,FOCB,FOCD,NRCOS,RLCOS
      REAL    SHC,SSHC,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TNRCOS,TRLCOS
C
C     *NONRECURRING COSTS
C
C     NRCOS(I,8) = 0.0
C
C    *RECURRING COSTS
C
      RLCOS(I,8) = RLCOS(I,8) + FOCB*NOB + FOCD*NOD
C
      RETURN
      END
```

```
      SUBROUTINE SYSOP(I,L)
C
C       THE SYSOP MODULE DETERMINES THE COST OF OPERATING THE GROUND
C       SYSTEM EQUIPMENT.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),NNGS(25),
     1              NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),
     1              NOKWHR,NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,LOGYR,NBAS,NDEP,NDS,NNGS,NOB,NOD,NRGS,NRL
      INTEGER NWS,YEAR
      REAL    AFHR,AMCOS,BIT,CPKWHR,DFHR,DIST,FBLRU,NOKWHR,NRCOS
      REAL    PQTY,RLCOS,RTSS,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TNRCOS
      REAL    TRLCOS,UCOS,UMTBF
C
C     *NONRECURRING COSTS
C
C     NRCOS(I,9) = 0.0
C
C     *RECURRING COSTS
C
      RLCOS(I,9) = RLCOS(I,9) + (TFOH(L)/AFHR)*NOKWHR*CPKWHR
C
      RETURN
      END
```

```
      SUBROUTINE OUTONE
C
C        THE SUBROUTINE OUTONE PRINTS THE LIFE CYCLE COSTS FOR THE
C         INDIVIDUAL SYSTEM TYPES EVALUATED.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/PARAM/BASEYR,DSCNT,NYRS,XDIS,XLRN,TDIS
C
C     *DECLARE VARIABLES
C
      INTEGER BASEYR,NYRS
      REAL    DSCNT,XDIS,XLRN
      LOGICAL*1 TDIS
C
C     *CALCULATE TOTALS FOR LIFE CYCLE
C
      CALL CUMTOT(NYRS)
C
C     *PRINT LIFE CYCLE COSTS FOR EACH SYSTEM TYPE IF DESIRED BY USER
C
      IF (TDIS .NE. 'Y') RETURN
      CALL PRTOUT(NYRS)
C
      RETURN
      END
```

```
C                          SUBROUTINE CUMTOT
C
C        THE CUMTOT MODULE CALCULATES THE TOTAL LOGISTIC SUPPORT
C        COSTS INCURRED EACH YEAR AND THE CUMULATIVE ACQUISITION,
C        INSTALLATION, AND LOGISTIC SUPPORT COSTS INCURRED PRIOR TO
C        YEAR I.
C
      SUBROUTINE CUMTOT(NYRS)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/CAT/CLCC, CPROG(25), TNRCAT(10), TPROG(25), TRLCAT(10)
      COMMON/INSTAL/ICOS(25), INCOS, RICOS, TCOSI(25), INYEAR
      COMMON/LOGIST/NRCOS(25,9), RLCOS(25,9), TCOSL(25), TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,NYRS,YEAR
      REAL ACOS,BIT,CLCC,CPROG,FBLRU,ICOS,INCOS,NRCOS,RICOS,RLCOS
      REAL RTSS,TCOSA,TCOSI,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TNRCAT,TNRCOS
      REAL TPROG,TRLCAT,TRLCOS,XDIS
C
C     *INITIALIZE VARIABLES
C
      DO 1 I = 1, NYRS
        TCOSA(I) = 0.0
        TCOSI(I) = 0.0
        TCOSN(I) = 0.0
        TCOSR(I) = 0.0
        TCOSL(I) = 0.0
        CPROG(I) = 0.0
1     CONTINUE
      DO 2 J = 1, 10
        TNRCAT(J) = 0.0
        TRLCAT(J) = 0.0
2     CONTINUE
      CLCC = 0.0
C
      DO 30 I = 1, NYRS
        DO 10 J = I, NYRS
C
C         *DETERMINE CUMULATIVE ACQUISITION COSTS
C
          TCOSA(J) = TCOSA(J) + ACOS(I)
C
C         *DETERMINE CUMULATIVE INSTALLATION COSTS
C
          TCOSI(J) = TCOSI(J) + ICOS(I)
```

```
C
C         *DETERMINE CUMULATIVE LOGISTIC SUPPORT COSTS
C
            TCOSN(J) = TCOSN(J) + TNRCOS(I)
            TCOSR(J) = TCOSR(J) + TRLCOS(I)
            TCOSL(J) = TCOSL(J) + TLLCOS(I)
C
C         *DETERMINE CUMULATIVE PROGRAM COSTS
C
            CPROG(J) = CPROG(J) + ACOS(I) + ICOS(I) + TLLCOS(I)
10        CONTINUE
C
C       *DETERMINE TOTAL PROGRAM COST FOR YEAR I
C
          TPROG(I) = TLLCOS(I) + ACOS(I) + ICOS(I)
C
C       *DETERMINE CUMULATIVE PROGRAM COST
C
          CLCC = CLCC + TPROG(I)
C
C       *DETERMINE TOTAL FOR EACH LOGISTIC CATEGORY
C
          DO 20 J = 1, 9
            TNRCAT(J) = TNRCAT(J) + NRCOS(I,J)
            TNRCAT(10) = TNRCAT(10) + NRCOS(I,J)
            TRLCAT(J) = TRLCAT(J) + RLCOS(I,J)
            TRLCAT(10) = TRLCAT(10) + RLCOS(I,J)
20        CONTINUE
30      CONTINUE
C
        RETURN
        END
```

```
      SUBROUTINE PRTOUT(NYRS)
C
C        THE PRTOUT MODULE PRINTS THE ANNUAL LABOR HOURS REQUIRED
C        FOR EACH SYSTEM TYPE, THE NUMBER OF PERSONNEL REQUIRED TO
C        MEET THAT EXPECTED DEMAND, AND THE COST OF THOSE PERSONNEL.
C        THE MODULE ALSO CALCULATES THE CUMULATIVE SUMS OF THE ABOVE
C        AND PRINTS THEM IN A SECOND TABLE.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/HOURS/BHOURS(25),CBHRS(25),CMHRS(25),DHOURS(25),DMHRS(25),
     1             PMHRS(25)
      COMMON/LCOSTS/BLABOR(25),CBCOST(25),CMCOST(25),DLABOR(25),
     1              DMCOST(25),PMCOST(25)
      COMMON/NAMES/NAMFAC,SNAME,UNAME
      COMMON/PRSNNL/BPERS(25),CBPER(25),CMPER(25),DMPER(25),DPERS(25),
     1              PMB,PMD,PMJ,PMPER(25),PRODB,PRODD,PRODJ,TCOSB,
     2              TCOSD,TCOSJ(6),TRB,TRD,TRJ(6)
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,NYRS,UB,YEAR
      INTEGER*4 NAMFAC(4)
      REAL    BHOURS,BIT,BLABOR,BPERS,TBCOS(25),TCBCOS(25),TCMCOS(25)
      REAL    TDCOS(25),TDMCOS(25),CMCOST,CMHRS,CMPER,TPMCOS(25)
      REAL    CBHR(25),CBASEP(25),CCBH(25),CCBPER(25),CCMH(25)
      REAL    CCMPER(25),CDHR(25),CDMH(25),CDMPER(25),CDEPPR(25)
      REAL    CPMH(25),CPMPER(25),DHOURS,DLABOR,DMCOST,DMPER,DPERS
      REAL    FBLRU,PMB,PMCOST,PMD,PMHRS,PMJ,PMPER,PRODB,PRODD
      REAL    PRODJ,RTSS,TCOS,TCOSB,TCOSD,TCOSJ,TCOSTS(25),TFOH
      REAL    THOURS(25),THRS,TRB,TRD,TRJ
      LOGICAL*1 SNAME(65),UNAME(35)
C
C     *INITIALIZE VARIABLES
C
      DO 1 I = 1, NYRS
        CBHR(I) = 0.0
        CCBH(I) = 0.0
        CCMH(I) = 0.0
        CDHR(I) = 0.0
        CDMH(I) = 0.0
        CPMH(I) = 0.0
        CBASEP(I) = 0.0
        CCBPER(I) = 0.0
        CCMPER(I) = 0.0
        CDMPER(I) = 0.0
        CDEPPR(I) = 0.0
        CPMPER(I) = 0.0
        TBCOS(I) = 0.0
```

```
        TCBCOS(I) = 0.0
        TCMCOS(I) = 0.0
        TDCOS(I) = 0.0
        TDMCOS(I) = 0.0
        TPMCOS(I) = 0.0
        THOURS(I) = 0.0
        TCOSTS(I) = 0.0
1     CONTINUE
      THRS = 0.0
      TCOS = 0.0
      NO = 3
      LB = 1
      UB = NYRS/NO
      NUM = NYRS - NO*(NYRS/NO)
C
C    *CALCULATE CUMULATIVE VALUES
C
      DO 7 I = 1, NYRS
        DO 5 J = I, NYRS
C
C         *DETERMINE CUMULATIVE MAINTENANCE LABOR HOURS
C
          CBHR(J) = CBHR(J) + BHOURS(I)
          CCBH(J) = CCBH(J) + CBHRS(I)
          CCMH(J) = CCMH(J) + CMHRS(I)
          CDHR(J) = CDHR(J) + DHOURS(I)
          CDMH(J) = CDMH(J) + DMHRS(I)
          CPMH(J) = CPMH(J) + PMHRS(I)
C
C         *DETERMINE CUMULATIVE MAINTENANCE PERSONNEL REQUIRED TO
C         *MEET EXPECTED DEMANDS
C
          CBASEP(J) = CBASEP(J) + BPERS(I)
          CCBPER(J) = CCBPER(J) + CBPER(I)
          CCMPER(J) = CCMPER(J) + CMPER(I)
          CDMPER(J) = CDMPER(J) + DMPER(I)
          CDEPPR(J) = CDEPPR(J) + DPERS(I)
          CPMPER(J) = CPMPER(J) + PMPER(I)
C
C         *DETERMINE CUMULATIVE MAINTENANCE LABOR COSTS
C
          TBCOS(J) = TBCOS(J) + BLABOR(I)
          TCBCOS(J) = TCBCOS(J) + CBCOST(I)
          TCMCOS(J) = TCMCOS(J) + CMCOST(I)
          TDCOS(J) = TDCOS(J) + DLABOR(I)
          TDMCOS(J) = TDMCOS(J) + DMCOST(I)
          TPMCOS(J) = TPMCOS(J) + PMCOST(I)
5       CONTINUE
C
C       *DETERMINE TOTAL LABOR HOURS AND COSTS INCURRED IN YEAR I
C
```

```
        THOURS(I) = THOURS(I) + BHOURS(I) + DHOURS(I) + DMHRS(I)
        TCOSTS(I) = TCOSTS(I) + BLABOR(I) + DLABOR(I) + DMCOST(I)
C
C      *DETERMINE TOTAL LABOR HOURS AND COSTS FOR LIFE CYCLE
C
        THRS = THRS + THOURS(I)
        TCOS = TCOS + TCOSTS(I)
7     CONTINUE
C
C    *PRINT HEADINGS
C
      WRITE(3,1001) (NAMFAC(J), J = 1, 4)
      WRITE(3,1002)
      N1 = 1
      N2 = NO
C
C    *PRINT LABOR HOURS, PERSONNEL, AND PERSONNEL COSTS FOR EACH YEAR
C    *BY CATEGORY
C
      DO 10 I = LB, UB
        WRITE(3,1003) (YEAR(J), J = N1, N2)
        WRITE(3,1015)
        WRITE(3,1004) ((CMHRS(J),CMPER(J),CMCOST(J)),J = N1, N2)
        WRITE(3,1005) ((PMHRS(J),PMPER(J),PMCOST(J)),J = N1, N2)
        WRITE(3,1022) ((CBHRS(J),CBPER(J),CBCOST(J)),J = N1, N2)
        WRITE(3,1023) ((DMHRS(J),DMPER(J),DMCOST(J)),J = N1, N2)
        WRITE(3,1006) ((BHOURS(J),BPERS(J),BLABOR(J)),J = N1, N2)
        WRITE(3,1007) ((DHOURS(J),DPERS(J),DLABOR(J)),J = N1, N2)
        WRITE(3,1025)  (THOURS(J),TCOSTS(J)),J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 10
        N2 = NYRS
        GO TO 20
10    CONTINUE
20    IF (NUM .EQ. 0) GO TO 30
      WRITE(3,1008) (YEAR(J),J = N1, N2)
      WRITE(3,1009)
      IF (NUM .EQ. 1) WRITE(3,1016)
      IF (NUM .EQ. 2) WRITE(3,1017)
      WRITE(3,1018)
      WRITE(3,1010) ((CMHRS(J),CMPER(J),CMCOST(J)),J = N1, N2)
      WRITE(3,1011) CCMH(NYRS),CCMPER(NYRS),TCMCOS(NYRS)
      WRITE(3,1012) ((PMHRS(J),PMPER(J),PMCOST(J)),J = N1, N2)
      WRITE(3,1011) CPMH(NYRS),CPMPER(NYRS),TPMCOS(NYRS)
      WRITE(3,1020) ((CBHRS(J),CBPER(J),CBCOST(J)),J = N1, N2)
      WRITE(3,1011) CCBH(NYRS),CCBPER(NYRS),TCBCOS(NYRS)
      WRITE(3,1021) ((DMHRS(J),DMPER(J),DMCOST(J)),J = N1, N2)
      WRITE(3,1011) CDMH(NYRS),CDMPER(NYRS),TDMCOS(NYRS)
      WRITE(3,1013) ((BHOURS(J),BPERS(J),BLABOR(J)),J = N1, N2)
      WRITE(3,1011) CBHR(NYRS),CBASEP(NYRS),TBCOS(NYRS)
```

```
      WRITE(3,1014) ((DHOURS(J),DPERS(J),DLABOR(J)), J = N1 ,N2)
      WRITE(3,1011) CDHR(NYRS),CDEPPR(NYRS),TDCOS(NYRS)
      WRITE(3,1026) ((THOURS(J),TCOSTS(J)),J = N1, N2)
      WRITE(3,1027) THRS, TCOS
      GO TO 40
C
30    WRITE(3,1019)
      WRITE(3,1004) CCMH(NYRS),CCMPER(NYRS),TCMCOS(NYRS)
      WRITE(3,1005) CPMH(NYRS),CPMPER(NYRS),TPMCOS(NYRS)
      WRITE(3,1022) CCBH(NYRS),CCBPER(NYRS),TCBCOS(NYRS)
      WRITE(3,1023) CDMH(NYRS),CDMPER(NYRS),TDMCOS(NYRS)
      WRITE(3,1006) CBHR(NYRS),CBASEP(NYRS),TBCOS(NYRS)
      WRITE(3,1007) CDHR(NYRS),CDEPPR(NYRS),TDCOS(NYRS)
      WRITE(3,1025) THOURS(NYRS),TCOSTS(NYRS)
C
C    *CONVERT ANNUAL TOTALS TO CUMULATIVES
C
40    DO 42 I = 2, NYRS
        THOURS(I) = THOURS(I) + THOURS(I-1)
        TCOSTS(I) = TCOSTS(I) + TCOSTS(I-1)
42    CONTINUE
C
C    *PRINT CUMULATIVE COSTS FOR SYSTEM TYPE BY YEAR AND CATEGORY
C
      WRITE(3,1001) (NAMFAC(J),J=1,4)
      WRITE(3,1024)
      N1 = 1
      N2 = NO
      DO 50 I = LB, UB+1
        WRITE(3,1003) (YEAR(J),J = N1, N2)
        IF ((I .EQ. (UB+1)) .AND. (NUM .EQ. 1)) WRITE(3,1016)
        IF ((I .EQ. (UB+1)) .AND. (NUM .EQ. 2)) WRITE(3,1017)
        IF (I .NE. (UB+1)) WRITE(3,1015)
        WRITE(3,1004) ((CCMH(J),CCMPER(J),TCMCOS(J)),J = N1, N2)
        WRITE(3,1005) ((CPMH(J),CPMPER(J),TPMCOS(J)),J = N1, N2)
        WRITE(3,1022) ((CCBH(J),CCBPER(J),TCBCOS(J)),J = N1, N2)
        WRITE(3,1023) ((CDMH(J),CDMPER(J),TDMCOS(J)),J = N1, N2)
        WRITE(3,1006) ((CBHR(J),CBASEP(J),TBCOS(J)),J = N1, N2)
        WRITE(3,1007) ((CDHR(J),CDEPPR(J),TDCOS(J)),J = N1, N2)
        WRITE(3,1028) ((THOURS(J),TCOSTS(J)),J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .GT. NYRS) N2 = NYRS
50    CONTINUE
C
C    *FORMAT STATEMENTS
C
1001  FORMAT(1H1,3X,'SYSTEM TYPE: ',4A4)
1002  FORMAT(1X,/,45X,'ANNUAL MAINTENANCE HOURS AND LABOR COSTS',//)
1003  FORMAT(1X,//,17X,3(18X,I4,15X),/)
1004  FORMAT(3X,'CORRECTIVE MAINT',2X,3(F12.0,F9.2,F12.0,4X))
```

```
1005  FORMAT(3X,'PREVENTIVE MAINT',2X,3(F12.0,F9.2,F12.0,4X))
1006  FORMAT(3X,'BASE LEVEL REPAIR',1X,3(F12.0,F9.2,F12.0,4X))
1007  FORMAT(3X,'DEPOT LEVEL REPAIR',3(F12.0,F9.2,F12.0,4X))
1008  FORMAT(1X,//,'$',16X,2(18X,I4,15X))
1009  FORMAT('+','TOTALS',/)
1010  FORMAT('$',2X,'CORRECTIVE MAINT',2X,2(F12.0,F9.2,F12.0,4X))
1011  FORMAT('+',F12.0,F9.2,F12.0)
1012  FORMAT('$',2X,'PREVENTIVE MAINT',2X,2(F12.0,F9.2,F12.0,4X))
1013  FORMAT('$',2X,'BASE LEVEL REPAIR',1X,2(F12.0,F9.2,F12.0,4X))
1014  FORMAT('$',2X,'DEPOT LEVEL REPAIR',2(F12.0,F9.2,F12.0,4X))
1015  FORMAT(3X,'LABOR CATEGORY',3(8X,'HOURS',4X,'MANPOWER',4X,'COST',
     1         4X))
1016  FORMAT('$',2X,'LABOR CATEGORY',8X,'HOURS',4X,'MANPOWER',4X,
     1         'COST',4X)
1017  FORMAT('$',2X,'LABOR CATEGORY',2(8X,'HOURS',4X,'MANPOWER',4X,
     1         'COST',4X))
1018  FORMAT('+',8X,'HOURS',4X,'MANPOWER',4X,'COST')
1019  FORMAT(34X,'TOTALS',/,3X,'LABOR CATEGORY',8X,'HOURS',4X,'MANPOWEI
     1        ,4X,'COST')
1020  FORMAT('$',2X,'CALL-BACK MAINT',3X,2(F12.0,F9.2,F12.0,4X))
1021  FORMAT('$',2X,'TOTAL SITE MAINT',2X,2(F12.0,F9.2,F12.0,4X))
1022  FORMAT(3X,'CALL-BACK MAINT',3X,3(F12.0,F9.2,F12.0,4X))
1023  FORMAT(3X,'TOTAL SITE MAINT',2X,3(F12.0,F9.2,F12.0,4X))
1024  FORMAT(1X,/,43X,'CUMULATIVE MAINTENANCE HOURS AND LABOR COSTS')
1025  FORMAT(3X,'TOTAL SYSTEM MAINT',3(F12.0,9X,F12.0,4X))
1026  FORMAT('$',2X,'TOTAL SYSTEM MAINT',2(F12.0,9X,F12.0,4X))
1027  FORMAT('+',F12.0,9X,F12.0)
1028  FORMAT(3X,'TOTAL SYSTEM MAINT',3(F12.0,9X,F12.0,4X))
C
      RETURN
      END
```

```
      SUBROUTINE OUTTWO
C
C       THE SUBROUTINE OUTTWO PRINTS THE LIFE CYCLE COSTS IN TABLE
C       FORM FOR THE INDIVIDUAL SYSTEMS IF DESIRED; OTHERWISE THE
C       RESULTS ARE SIMPLY SAVED VIA THE ROUTINE SAVDAT.
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/PARAM/BASEYR,DSCNT,NYRS,XDIS,XLRN,TDIS
C
C     *DECLARE VARIABLES
C
      INTEGER BASEYR,NYRS
      REAL DSCNT,XDIS,XLRN
      LOGICAL*1 TDIS
C
      IF (TDIS .EQ. 'Y') CALL TABLES(NYRS,DSCNT,1)
      CALL DATSAV(NYRS)
C
      RETURN
      END
```

```
C                          SUBROUTINE TABLES
C
C        THE TABLES MODULE OUTPUTS ALL OF THE VALUES COMPUTED IN
C        THE LIFE CYCLE COSTING MODEL IN TABULAR FORM.
C
      SUBROUTINE TABLES(NYRS,DSCNT,OUT)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/CAT/CLCC, CPROG(25), TNRCAT(10), TPROG(25), TRLCAT(10)
      COMMON/INSTAL/ICOS(25), INCOS, RICOS, TCOSI(25), INYEAR
      COMMON/LOGIST/NRCOS(25,9), RLCOS(25,9), TCOSL(25), TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/NAMES/NAMFAC,SNAME,UNAME
      COMMON/SYSDAT/AFHR,AMCOS,CPKWHR,DFHR,DIST,NDS(3),NOKWHR,
     1              NRL(25,3),NWS(3),PQTY,UCOS,UMTBF
C
C     *DECLARE VARIABLES
C
      INTEGER GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,OUT,UB,YEAR
      INTEGER*4 NAMFAC(4)
      REAL ACOS,BIT,CLCC,CPROG,FBLRU,ICOS,INCOS,NRCOS,RICOS,RLCOS
      REAL RTSS,TCOSA,TCOSI,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS,TPROG,TNRCAT
      REAL TNRCOS,TRLCAT,TRLCOS,NOKWHR
      LOGICAL*1 ANS, SNAME(65), UNAME(35)
C
C     *INITIALIZE VARIABLES
C
      NO = 5
      LB = 1
      UB = (NYRS/NO) - 1
      NUM = NYRS - NO*(NYRS/NO)
      IF (NUM .EQ. 0) UB = NYRS/NO
C
      IF (DSCNT .NE. 0) GO TO 1
      WRITE(1,*)'DO YOU WANT A NONRECURRING/RECURRING COST BREAKDOWN OF'
      IF (OUT .EQ. 0) WRITE(1,*) 'THE TOTAL SYSTEM RESULTS?'
      IF (OUT.NE.0) WRITE(1,*) 'THE SYSTEM CURRENTLY UNDER EVALUATION?'
      GO TO 2
1     IF (DSCNT .EQ. 0) GO TO 2
      WRITE(1,*) 'DO YOU WANT A NONRECURRING/RECURRING COST BREAKDOWN'
      WRITE(1,*) 'OF THE DISCOUNTED FIGURES?'
2     READ(1,1050) ANS
      WRITE(1,*) '  '
      IF (ANS .NE. 'Y') GO TO 27
C     *PRINT HEADINGS, INVESTMENT COSTS
C
      IF (OUT .EQ. 0) WRITE(3,1034) (SNAME(I), I = 1,65)
      IF (OUT .NE. 0) WRITE(3,1044) (NAMFAC(J),J=1,4)
```

```
      WRITE(3,1035) (UNAME(I), I = 1,35)
      WRITE(3,1036) DSCNT
      WRITE(3,1000)
      N1 = 1
      N2 = NO
C
C    *PRINT NONRECURRING COSTS FOR EACH YEAR BY CATEGORY
C
      DO 10 I = LB, UB
        WRITE(3,1001) (YEAR(J), J = N1, N2)
        WRITE(3,1002) (NRCOS(J,1), J = N1, N2)
        WRITE(3,1045) (NRCOS(J,3), J = N1, N2)
        WRITE(3,1005) (NRCOS(J,4), J = N1, N2)
        WRITE(3,1006) (NRCOS(J,5), J = N1, N2)
        WRITE(3,1007) (NRCOS(J,6), J = N1, N2)
        WRITE(3,1008) (NRCOS(J,7), J = N1, N2)
        WRITE(3,1009) (NRCOS(J,8), J = N1, N2)
        WRITE(3,1010) (TNRCOS(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 10
        N2 = NYRS
        GO TO 15
10    CONTINUE
15    WRITE(3,1026) (YEAR(J),J = N1, N2)
      WRITE(3,1027)
      WRITE(3,1012) (NRCOS(J,1), J = N1, N2)
      WRITE(3,1013) TNRCAT(1)
      WRITE(3,1046) (NRCOS(J,3), J = N1, N2)
      WRITE(3,1013) TNRCAT(3)
      WRITE(3,1016) (NRCOS(J,4), J = N1, N2)
      WRITE(3,1013) TNRCAT(4)
      WRITE(3,1017) (NRCOS(J,5), J = N1, N2)
      WRITE(3,1013) TNRCAT(5)
      WRITE(3,1018) (NRCOS(J,6), J = N1, N2)
      WRITE(3,1013) TNRCAT(6)
      WRITE(3,1019) (NRCOS(J,7), J = N1, N2)
      WRITE(3,1013) TNRCAT(7)
      WRITE(3,1020) (NRCOS(J,8), J = N1, N2)
      WRITE(3,1013) TNRCAT(8)
      WRITE(3,1021) (TNRCOS(J), J = N1, N2)
      WRITE(3,1013) TNRCAT(10)
C
C    *PRINT HEADINGS, OPERATING AND SUPPORT COSTS
C
      IF (OUT .EQ. 0) WRITE(3,1034) (SNAME(I), I = 1, 65)
      IF (OUT .NE. 0) WRITE(3,1044) (NAMFAC(J),J=1,4)
      WRITE(3,1035) (UNAME(I), I = 1, 35)
      WRITE(3,1036) DSCNT
      WRITE(3,1028)
      N1 = 1
      N2 = NO
```

```
C
C     *PRINT RECURRING COSTS FOR EACH CATEGORY BY YEAR
C
      DO 20 I = LB, UB
        WRITE(3,1001) (YEAR(J), J = N1, N2)
        WRITE(3,1002) (RLCOS(J,1), J = N1, N2)
        WRITE(3,1003) (RLCOS(J,2), J = N1, N2)
        WRITE(3,1004) (RLCOS(J,3), J = N1, N2)
        WRITE(3,1005) (RLCOS(J,4), J = N1, N2)
        WRITE(3,1006) (RLCOS(J,5), J = N1, N2)
        WRITE(3,1007) (RLCOS(J,6), J = N1, N2)
        WRITE(3,1008) (RLCOS(J,7), J = N1, N2)
        WRITE(3,1009) (RLCOS(J,8), J = N1, N2)
        WRITE(3,1042) (RLCOS(J,9), J = N1, N2)
        WRITE(3,1010) (TRLCOS(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 20
        N2 = NYRS
        GO TO 25
20    CONTINUE
25    WRITE(3,1026) (YEAR(J), J = N1, N2)
      WRITE(3,1027)
      WRITE(3,1012) (RLCOS(J,1), J = N1, N2)
      WRITE(3,1013) TRLCAT(1)
      WRITE(3,1014) (RLCOS(J,2), J = N1, N2)
      WRITE(3,1013) TRLCAT(2)
      WRITE(3,1015) (RLCOS(J,3), J = N1, N2)
      WRITE(3,1013) TRLCAT(3)
      WRITE(3,1016) (RLCOS(J,4), J = N1, N2)
      WRITE(3,1013) TRLCAT(4)
      WRITE(3,1017) (RLCOS(J,5), J = N1, N2)
      WRITE(3,1013) TRLCAT(5)
      WRITE(3,1018) (RLCOS(J,6), J = N1, N2)
      WRITE(3,1013) TRLCAT(6)
      WRITE(3,1019) (RLCOS(J,7), J = N1, N2)
      WRITE(3,1013) TRLCAT(7)
      WRITE(3,1020) (RLCOS(J,8), J = N1, N2)
      WRITE(3,1013) TRLCAT(8)
      WRITE(3,1043) (RLCOS(J,9), J = N1, N2)
      WRITE(3,1013) TRLCAT(9)
      WRITE(3,1021) (TRLCOS(J), J = N1, N2)
      WRITE(3,1013) TRLCAT(10)
C
C     *PRINT HEADINGS FOR TOTAL LIFE CYCLE COSTS BY YEAR
C
27    IF (OUT .EQ. 0) WRITE(3,1034) (SNAME(I), I = 1, 65)
      IF (OUT .NE. 0) WRITE(3,1044) (NAMFAC(J),J=1,4)
      WRITE(3,1035) (UNAME(I), I = 1, 35)
      WRITE(3,1036) DSCNT
      IF (OUT .NE. 0) WRITE(3,1011) UCOS,UMTBF
      WRITE(3,1029)
```

```
      N1 = 1
      N2 = NO
C
C    *PRINT RESULTS
C
      DO 30 I = LB, UB
        WRITE(3,1001) (YEAR(J), J = N1, N2)
        WRITE(3,1030) (ACOS(J), J = N1, N2)
        WRITE(3,1031) (ICOS(J), J = N1, N2)
        WRITE(3,1037) (TNRCOS(J), J = N1, N2)
        WRITE(3,1038) (TRLCOS(J), J = N1, N2)
        WRITE(3,1032) (TLLCOS(J), J = N1, N2)
        WRITE(3,1033) (TPROG(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 30
        N2 = NYRS
        GO TO 35
30    CONTINUE
35    WRITE(3,1026) (YEAR(J), J = N1, N2)
      WRITE(3,1027)
      WRITE(3,1022) (ACOS(J), J = N1, N2)
      WRITE(3,1013) TCOSA(NYRS)
      WRITE(3,1023) (ICOS(J), J = N1, N2)
      WRITE(3,1013) TCOSI(NYRS)
      WRITE(3,1040) (TNRCOS(J), J = N1, N2)
      WRITE(3,1013) TCOSN(NYRS)
      WRITE(3,1041) (TRLCOS(J), J = N1, N2)
      WRITE(3,1013) TCOSR(NYRS)
      WRITE(3,1024) (TLLCOS(J), J = N1, N2)
      WRITE(3,1013) TCOSL(NYRS)
      WRITE(3,1025) (TPROG(J), J = N1, N2)
      WRITE(3,1013) CLCC
C
C    *PRINT HEADINGS FOR CUMULATIVE LIFE CYCLE COSTS BY YEAR
C
      WRITE(3,1037)
      N1 = 1
      N2 = NO
C
C    *PRINT RESULTS
C
      IF (NUM .EQ. 0) UB = UB - 1
      DO 40 I = LB, UB+1
        WRITE(3,1001) (YEAR(J), J = N1, N2)
        WRITE(3,1030) (TCOSA(J), J = N1, N2)
        WRITE(3,1031) (TCOSI(J), J = N1, N2)
        WRITE(3,1037) (TCOSN(J), J = N1, N2)
        WRITE(3,1038) (TCOSR(J), J = N1, N2)
        WRITE(3,1032) (TCOSL(J), J = N1, N2)
        WRITE(3,1033) (CPROG(J), J = N1, N2)
```

```
      N1 = N1 + NO
      N2 = N2 + NO
      IF (N2 .LT. NYRS) GO TO 40
      N2 = NYRS
40    CONTINUE
C
C     *FORMAT STATEMENTS
C
1000  FORMAT(49X,'NONRECURRING LOGISTIC SUPPORT COSTS',//)
1001  FORMAT(1X,//,9X,'COST CATEGORY  ', 2X, 7(6X,I4,5X),/)
1002  FORMAT(9X,'SPARES          ', 8(2X,F13.0))
1003  FORMAT(9X,'ON-SITE MAINT   ', 8(2X,F13.0))
1004  FORMAT(9X,'OFF-SITE MAINT  ', 8(2X,F13.0))
1005  FORMAT(9X,'INVENTORY MGT   ', 8(2X,F13.0))
1006  FORMAT(9X,'SUPPORT EQUIP   ', 8(2X,F13.0))
1007  FORMAT(9X,'TRAINING        ', 8(2X,F13.0))
1008  FORMAT(9X,'DATA MANAGEMENT', 8(2X,F13.0))
1009  FORMAT(9X,'FACILITIES      ', 8(2X,F13.0))
1010  FORMAT(9X,'ANNUAL TOTAL    ', 8(2X,F13.0))
1011  FORMAT(4X,'SYSTEM COST: $',F10.2,'   SYSTEM MTBF: ',F8.1)
1012  FORMAT('$',8X,'SPARES          ',8(2X,F13.0))
1013  FORMAT('+',2X,F13.0)
1014  FORMAT('$',8X,'ON-SITE MAINT   ',8(2X,F13.0))
1015  FORMAT('$',8X,'OFF-SITE MAINT  ',8(2X,F13.0))
1016  FORMAT('$',8X,'INVENTORY MGT   ',8(2X,F13.0))
1017  FORMAT('$',8X,'SUPPORT EQUIP   ',8(2X,F13.0))
1018  FORMAT('$',8X,'TRAINING        ',8(2X,F13.0))
1019  FORMAT('$',8X,'DATA MANAGEMENT',8(2X,F13.0))
1020  FORMAT('$',8X,'FACILITIES      ',8(2X,F13.0))
1021  FORMAT('$',8X,'ANNUAL TOTAL    ',8(2X,F13.0))
1022  FORMAT('$',8X,'ACQUISITION     ',8(2X,F13.0))
1023  FORMAT('$',8X,'INSTALLATION    ',8(2X,F13.0))
1024  FORMAT('$',8X,'TOTAL LOGISTIC  ',8(2X,F13.0))
1025  FORMAT('$',8X,'TOTAL PROGRAM   ',8(2X,F13.0))
1026  FORMAT(1X,//,'$',8X,'COST CATEGORY  ',2X,7(6X,I4,5X))
1027  FORMAT('+',2X,'TOTAL')
1028  FORMAT(52X,'RECURRING LOGISTIC SUPPORT COSTS',//)
1029  FORMAT(56X,'TOTAL LIFE CYCLE COSTS BY YEAR')
1030  FORMAT(9X,'ACQUISITION     ',8(2X,F13.0))
1031  FORMAT(9X,'INSTALLATION    ',8(2X,F13.0))
1032  FORMAT(9X,'TOTAL LOGISTIC  ',8(2X,F13.0))
1033  FORMAT(9X,'TOTAL PROGRAM   ',8(2X,F13.0))
1034  FORMAT(1H1,3X,'SYSTEM: ',65A1)
1035  FORMAT(4X,'USER:     ',35A1)
1036  FORMAT(4X,'DISCOUNT FACTOR:',F4.2)
1037  FORMAT(9X,'NONRECURRING    ',8(2X,F13.0))
1038  FORMAT(9X,'RECURRING       ',8(2X,F13.0))
1039  FORMAT(1X,//,50X,'CUMULATIVE LIFE CYCLE COSTS BY YEAR')
1040  FORMAT('$',8X,'NONRECURRING    ',8(2X,F13.0))
1041  FORMAT('$',8X,'RECURRING       ',8(2X,F13.0))
```

```
1042  FORMAT(9X,'SITE OPERATION ',8(2X,F13.0))
1043  FORMAT('$',8X,'SITE OPERATION ',8(2X,F13.0))
1044  FORMAT(1H1,3X,'SYSTEM: ',4A4)
1045  FORMAT(9X,'SHIPPING       ',8(2X,F13.0))
1046  FORMAT('$',8X,'SHIPPING       ',8(2X,F13.0))
1050  FORMAT(10A1)
      RETURN
      END
```

```
C                          SUBROUTINE DATSAV
C
C        THE SAVDAT MODULE ACCUMULATES THE LIFE CYCLE COSTS OF
C        EACH FACILITY TYPE EVALUATED SO THAT TOTALS MAY BE
C        PRINTED FOLLOWING THE OUTPUT OF THE INDIVIDUAL FACILITY
C        LIFE CYCLE COSTS (OPTIONAL).
C
      SUBROUTINE DATSAV(NYRS)
C
C     *DECLARE COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25),TCOSA(25)
      COMMON/INSTAL/ICOS(25),INCOS,RICOS,TCOSI(25),INYEAR
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/SAVEIT/SACOS(25),SICOS(25),SNRCOS(25,9),SRLCOS(25,9),
     1              STLLCO(25),STNRCO(25),STRLCO(25)
C
C     *DECLARE VARIABLES
C
      REAL ICOS, INCOS, NRCOS
      DATA SACOS,SICOS,SNRCOS,SRLCOS,STLLCO,STNRCO,STRLCO/575*0.0/
C
C     *TRANSFER INDIVIDUAL FACILITY LIFE CYCLE COST DATA TO CUMULATIVE
C     *ARRAYS FOR STORAGE AND RE-INITIALIZE PROGRAM COST ARRAYS TO ZERO.
C
      DO 20 I = 1, NYRS
        SACOS(I) = SACOS(I) + ACOS(I)
        SICOS(I) = SICOS(I) + ICOS(I)
        STLLCO(I) = STLLCO(I) + TLLCOS(I)
        STNRCO(I) = STNRCO(I) + TNRCOS(I)
        STRLCO(I) = STRLCO(I) + TRLCOS(I)
        ACOS(I) = 0.0
        ICOS(I) = 0.0
        TLLCOS(I) = 0.0
        TNRCOS(I) = 0.0
        TRLCOS(I) = 0.0
        DO 10 J = 1, 9
          SNRCOS(I,J) = SNRCOS(I,J) + NRCOS(I,J)
          SRLCOS(I,J) = SRLCOS(I,J) + RLCOS(I,J)
          NRCOS(I,J) = 0.0
          RLCOS(I,J) = 0.0
10      CONTINUE
20    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE OUTTHR
C
C        THE SUBROUTINE OUTTWO PRINTS THE RESULTS FOR THE TOTAL
C        LIFE CYCLE COSTS OF ALL SYSTEMS EVALUATED.
C
C    *ESTABLISH COMMON BLOCKS
C
      COMMON/PARAM/BASEYR,DSCNT,NYRS,XDIS,XLRN,TDIS
C
C    *DECLARE VARIABLES
C
      INTEGER BASEYR,NYRS
      REAL DSCNT,XDIS,XLRN
      LOGICAL*1 TDIS
C
C    *PRINT RESULTS FOR LIFE CYCLE
C
      CALL UNDSAV(NYRS)
      CALL CUMTOT(NYRS)
      CALL TABLES(NYRS,DSCNT,0)
C
      WRITE(1,*) 'DO YOU WISH TO PRINT THE DISCOUNTED FIGURES'
      WRITE(1,*) 'FOR THE TOTAL LIFE CYCLE EVALUATION?'
      READ(1,1001) TDIS
      WRITE(1,*) '  '
      IF (TDIS .NE. 'Y') RETURN
C
C    *CALCULATE AND PRINT DISCOUNTED ANNUAL LOGISTIC SUPPORT COSTS
C    *BY CATEGORY AND DISCOUNTED TOTAL LIFE CYCLE COSTS BY YEAR
C
      CALL DSCONT(NYRS,XDIS,BASEYR)
      CALL CUMTOT(NYRS)
      CALL TABLES(NYRS,XDIS,0)
C
C    *FORMAT STATEMENTS
C
1001  FORMAT(1A1)
C
      RETURN
      END
```

```
C                         SUBROUTINE UNDSAV
C
C          THE UNDSAV MODULE RESTORES THE ACCUMULATED LIFE CYCLE COSTS
C          TO THE ORIGINAL COST ARRAYS FOR OUTPUT PURPOSES.
C
      SUBROUTINE UNDSAV(NYRS)
C
C     *DECLARE COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25),TCOSA(25)
      COMMON/INSTAL/ICOS(25),INCOS,RICOS,TCOSI(25),INYEAR
      COMMON/LOGIST/NRCOS(25,9),RLCOS(25,9),TCOSL(25),TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRLOS(25),TRLCOS(25),LOCYR
      COMMON/SAVEIT/SACOS(25),SICOS(25),SNRCOS(25,9),SRLCOS(25,9),
     1              STLLCO(25),STNRCO(25),STRLCO(25)
C
C     *DECLARE VARIABLES
C
      REAL ICOS,INCOS,NRCOS
C
C     *RESTORE DATA TO ORIGINAL ARRAYS
C
      DO 20 I = 1, NYRS
        ACOS(I) = SACOS(I)
        ICOS(I) = SICOS(I)
        TLLCOS(I) = STLLCO(I)
        TNRCOS(I) = STNRCO(I)
        TRLCOS(I) = STRLCO(I)
        DO 10 J = 1, 9
          NRCOS(I,J) = SNRCOS(I,J)
          RLCOS(I,J) = SRLCOS(I,J)
10      CONTINUE
20    CONTINUE
      RETURN
      END
```

```
C                              SUBROUTINE DSCONT
C
C       THE DSCONT MODULE DISCOUNTS THE ACQUISITION, INSTALLATION,
C       NONRECURRING AND RECCURRING LOGISTIC COSTS FOR ALL YEARS
C       AND CATEGORIES.
C       *NOTE: THE CONSTANT DOLLAR COST ARRAY VALUES ARE CHANGED
C       DUE TO THE USE OF THE COMMON STATEMENT.
C
      SUBROUTINE DSCONT(NYRS,XDIS,BASEYR)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ANNDAT/BIT,FBLRU,GSYS(25),NBAS(25),NDEP(25),
     1              NNGS(25),NOB,NOD,NRGS(25),RTSS,TFOH(25),YEAR(25)
      COMMON/INSTAL/ICOS(25), INCOS, RICOS, TCOSI(25), INYEAR
      COMMON/LOGIST/NRCOS(25,9), RLCOS(25,9), TCOSL(25), TCOSN(25),
     1              TCOSR(25),TLLCOS(25),TNRCOS(25),TRLCOS(25),LOGYR
      COMMON/CAT/CLCC, CPROG(25), TNRCAT(10), TPROG(25), TRLCAT(10)
C
C     *DECLARE VARIABLES
C
      INTEGER BASEYR,GSYS,NBAS,NDEP,NNGS,NOB,NOD,NRGS,NYRS,YEAR
      REAL    ACOS,BIT,CLCC,CPROG,DISC,FBLRU,ICOS,INCOS,NRCOS,RLCOS
      REAL    RICOS,RTSS,TCOSA,TCOSI,TCOSL,TCOSN,TCOSR,TFOH,TLLCOS
      REAL    TNRCAT,TNRCOS,TPROG,TRLCAT,TRLCOS,XDIS
C
      DO 20 I = 1, NYRS
C
C      *COMPUTE THE DISCOUNT FACTOR FOR YEAR I
C
        N = YEAR(I) - BASEYR
        DISC = (1/(1+XDIS))**N
C
C      *DISCOUNT ALL COST ARRAYS
C
        ACOS(I) = ACOS(I)*DISC
        ICOS(I) = ICOS(I)*DISC
        TPROG(I) = TPROG(I)*DISC
        TNRCOS(I) = TNRCOS(I)*DISC
        TRLCOS(I) = TRLCOS(I)*DISC
        TLLCOS(I) = TLLCOS(I)*DISC
        DO 10 J = 1, 9
          NRCOS(I,J) = NRCOS(I,J)*DISC
          RLCOS(I,J) = RLCOS(I,J)*DISC
10      CONTINUE
20    CONTINUE
C
      RETURN
      END
```

APPENDIX F

PARAMETER SUMMARY
FOR LIFE-CYCLE-COST MODEL
FOR GROUND EQUIPMENT

VARIABLE	DESCRIPTION	VALUE
AFHR	Avg. annual operating hours per system type	8760.
AMCOS	Amortization cost	0
$AVALB_L$	Availability of Lth type base support equipment	25%
$AVALD_L$	Availability of Lth type depot support equipment	25%
BASEYR	Base year for discounting purposes	1980
$BETA_L$	Lth type base support equipment time available per month (hrs.)	160
BIT	Fraction of failures isolated to LRU by Built In Test Equipment	1.0
BLR	Avg. annual salary, base repair personnel	$36,234.
BMC_J	Avg. base materials cost per maintenance action on Jth LRU	System Variable
$BMCS_{J,K}$	Avg. base materials cost per maintenance action on $SRU_{J,K}$	System Variable
BMT	Avg. base turnaround time (mo.)	0.17 mo.
BSOB	Base SRU stocking objective (mo.)	1.00 mo.
BSOBL	Base LRU stocking objective (mo.)	N/A
BSOD	Depot SRU stocking objective (mo.)	N/A
BSODL	Depot LRU stocking objective (mo.)	N/A
$COND_J$	Fraction of LRU_J failures resulting in condemnations	System Variable
$CONDB_{J,K}$	Fraction of $SRU_{J,K}$ failures resulting in condemnations	System Variable
CMILES	Avg. distance travelled to sites for CM (mi.)	76. miles
CPKWHR	Cost per kilowatt-hour	$0.043/kWhr
CPMI	Cost per mile	$0.20/mile
CPNP	Cost per new page of technical documentation	$400.

NOTE: A "BASE" represents a maintenance hub; a "DEPOT" represents an MLS manufacturer.

VARIABLE	DESCRIPTION	VALUE
CPP	Cost per page of original technical documentation	$400.
$DETA_L$	Lth type depot support equipment time available per month (hrs.)	160
DFHR	Avg. daily operating hours per system type	24
DIST	FAA factory inspection mark-up	0.03
DLR	Avg. annual salary, depot repair personnel	$42,907.
DMC_J	Avg. depot materials cost per maintenance action on Jth LRU	System Variable
$DMCS_{J,K}$	Avg. depot materials cost per maintenance action on $SRU_{J,K}$	System Variable
DMT	Depot turnaround time (mo.)	3.0 mo.
FITT	Avg. labor-hours to fault isolate and test at system site	System Variable
FOCB	Annual base facilities cost attributable to system being analyzed	System Variable
FOCD	Annual depot facilities cost attributable to system being analyzed	System Variable
FTS	Fraction of failures repaired on-site	5%
HOLD	Avg. annual holding cost per item type	$150.
IAMC	Cost of introducing each new inventory coded item	$1200.
INCOS	Installation cost of system at new sites	System Variable
INYEAR	Number of years between system acquisition and installation	2
$ISPR_J$	Spare flag for Jth LRU	System Variable
$ISPRB_{J,K}$	Spare flag for $SRU_{J,K}$	System Variable
$ITWL_J$	Repair/throw-away flag for Jth LRU	System Variable
$ITWS_{J,K}$	Repair/throw-away flag for $SRU_{J,K}$	System Variable
JSEB	No. of different types of base support equipment	1
JSED	No. of different types of depot support equipment	1

VARIABLE	DESCRIPTION	VALUE
$LABOR_M$	Name of Mth labor skill level	Journeyman
$LCOMB_L$	No. of system types to which Lth type base support equipment is common	System Variable
$LCOMD_L$	No. of system types to which Lth type depot support equipment is common	System Variable
$LCOML_J$	No. of system types to which Jth LRU is common	System Variable
$LCOMS_{J,K}$	No. of system types to which $SRU_{J,K}$ is common	System Variable
LDIST	Percentage markup on LRUs by distributors	0.0
LMKUP	Percentage markup on LRUs by repair shops	0.0
$LMTBF_J$	Mean time between failures (MTBF) of LRU_J (program internal)	System Variable
$LMTTR_J$	Mean time to repair LRU_J	System Variable
LOGYR	Number of years between system acquisition and logistic support requirements	2
$LUCOS_J$	Unit cost of LRU_J (program internal)	System Variable
MES_N	Week-end maintenance shift identifier, restoration level N (program internal)	System Variable
MINB	Minimum no. of each type LRU at base and depot	Ø
MINBP	Minimum no. of base repair personnel	1
MINDP	Minimum no. of depot repair personnel	1
MINJP	Minimum no. of travelling repair personnel	6
MINSEB	Minimum no. of support equipment sets per type per base	1
MINSED	Minimum no. of support equipment sets per type per depot	1
MS_N	Daily maintenance shift identifier restoration level N (program internal)	System Variable
$MSEBO_L$	Minimum annual operating cost, Lth type base support equipment	System Variable
$MSEDO_L$	Minimum annual operating cost, Lth type depot support equipment	System Variable

VARIABLE	DESCRIPTION	VALUE
MTRR	Mean time to remove and replace failed component at site	1.0 hr.
MTTR	Mean time to repair failed component at site	System Variable
NAMFAC	Name of system being analyzed	System Variable
$NBAS_I$	No. of base repair facilities in year I	75
$NDEP_I$	No. of depot repair facilities in year I	3
NDS_N	No. of daily maintenance shifts for system site having restoration level N	Variable
NFT	No. of different systems to be evaluated	Variable
NLRU	No. of LRUs per system type	System Variable
$NNGS_I$	No. of systems installed in new sites in year I	System Variable
NNIC	No. of new inventory coded items	Variable
NNPBD	No. of new pages of base level documentation	10
NNPDD	No. of new pages of depot level documentation	10
NOKWHR	No. of kilowatt-hours consumed annually per system type	System Variable
$NOSRU_{J,K}$	No. of like $SRU_{J,K}$s in LRU_J	System Variable
NPBD	No. of pages base level documentation	500
NPDD	No. of pages depot level documentation	600
$NRGS_I$	No. of systems retrofit in existing sites in year I	0
$NRL_{I,N}$	No. of sites having restoration level N in year I	0
NSCAT	Index of repair skill level required for on-site maintenance	1
NSL	No. of skill levels of repair for on-site maintenance	1
$NSRU_J$	No. of SRU types in Jth LRU	System Variable

VARIABLE	DESCRIPTION	VALUE
NWS_N	No. of week-end shifts for sites having restoration level N	Variable
NYRS	No. of years in life cycle	25
$OTSLR_M$	Avg. annual salary at overtime rate, skill level M	N/A
OSB	Avg. SRU order/ship time at base (mo.)	0.17 mo.
OSBL	Avg. LRU order/ship time at base (mo.)	3.00 mo.
OSD	Avg. SRU order/ship time at depot (mo.)	N/A
OSDL	Avg. LRU order/ship time at depot (mo.)	3.00 mo.
PACK	Packaging factor (packed wt./unpacked wt.)	1.125
$PCON_N$	Probability of contact for facility type having restoration level N	Variable
PD_N	Daily failure allocation factor, restoration level N (program internal)	System Variable
PE_N	Week-end failure allocation factor, restoration level N (program internal)	System Variable
PMB	Available hours per year per man at base	2080. hrs.
PMD	Available hours per year per man at depot	2080. hrs.
PMILES	Avg. distance travelled to sites for PM	76. r'
PMJ	Available hours per year per journeying repair person	2080. hrs.
PMMH	Avg. preventive maintenance labor-hours	System Variable
PQTY	Production lot size per manufacturer per year	System Variable
PRODB	Producti ' of base level repair personnel	0.85
PRODD	Productivity of depot level repair personnel	0.85
PRODJ	Productivity of journeying repair personnel	0.70
RICOS	Retrofit installation cost of system	N/A

VARIABLE	DESCRIPTION	VALUE
RLF_N	Non-regular shift maintenance action demands, restoration level N (program internal)	System Variable
ROP	Requirements objectives period (mo.)	N/A
$RTLB_J$	Fraction of LRU_J failures repaired at base	System Variable
RTS_J	Fraction of LRU_J failures isolated to SRU at base	System Variable
$RTSB_{J,K}$	Fraction of repairable $SRU_{J,K}$ repaired at base	System Variable
RTSS	Fraction of failures isolated to LRU at base	System Variable
$SDIF_M$	Shift differential, skill level M	1.25
SDIST	Percentage markup on SRUs by distributors	N/A
$SECOB_L$	Lth type base support equipment operating cost	System Variable
$SECOD_L$	Lth type depot support equipment operating cost	System Variable
$SFITT_{J,K}$	Avg. time to fault-isolate and test $SRU_{J,K}$	System Variable
SHC	Shipping rate to first destination ($/lb-zone)	$0.067
SLR_M	Avg. annual salary for technicians of repair skill level M	$30,329.
SMKUP	Percentage markup on SRUs by repair facilities	N/A
SMMHC	Total CM labor-hours per action per system type (program internal)	System Variable
SMMHP	Total call-backs CM labor-hours per action per system tape (program internal)	System Variable
$SMTBF_{J,K}$	MTBF for $SRU_{J,K}$	System Variable
$SMTTR_{J,K}$	Mean time to repair $SRU_{J,K}$	System Variable
SSHC	Shipping rate between base and depot ($/lb-zone)	$0.067
$SUCOS_{J,K}$	Unit cost of $SRU_{J,K}$	System Variable
SUF(1)	Repair personnel sufficiency factor	0.84

VARIABLE	DESCRIPTION	VALUE
SUF(2)	LRU spares sufficiency factor	N/A
SUF(3)	SRU spares sufficiency factor	0.50
SYSWT	Weight of total system (lb) (program internal)	System Variable
TCOSB	Training cost per base repair person	$2200.
TCOSD	Training cost per depot repair person	N/A
$TCOSJ_M$	Training cost per Mth skill level repair person	$1450.
TRB	Personnel turnover rate at base	0.10
TRD	Personnel turnover rate at depot	N/A
TRJ_M	Personnel turnover rate, skill level M	0.10
TRT	Avg. authorized travel time from central location to system site	2.17 hrs.
TRTD	Avg. authorized travel time to site for daily PM	N/A
TRTP	Avg. authorized travel time to site for call-backs	N/A
UCOS	Unit cost of system (program internal)	System Variable
UMTBF	MTBF of system (program internal)	System Variable
$USECOS_L$	Unit cost of Lth type base support equipment	$5000.
$USECOD_L$	Unit cost of Lth type depot support equipment	$5000.
$UTILB_L$	Utilization rate of Lth type base support equipment	95%
$UTILD_L$	Utilization rate of Lth type depot support equipment	95%
WT_J	Weight of Jth LRU (lb)	System Variable
$WTB_{J,K}$	Weight of $SRU_{J,K}$ (lb)	System Variable
XDIS	Discount rate	0.10
XLRN	Learning curve factor	0.875

VARIABLE	DESCRIPTION	VALUE
XMIL	Avg. no. of shipping zones between base and depot	1
XMINB	Minimum no. of each type SRU at base at depot	1
$YEAR_I$	Year array	1985-2009
YMIL	Avg. no of shipping zones to first destination	1

APPENDIX G

MATHEMATICAL FORMULATION OF THE COST MODEL FOR AIRBORNE EQUIPMENT

CONTENTS

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3.	MODEL FORMULATION	G-6

1. GENERAL DESCRIPTION

ARINC Research Corporation's Life Cycle Cost Model for Airborne Equipment (ALCCM) has been adapted to evaluate the economic impact of proposed Microwave Landing Systems (MLS). The model evaluates three different MLS systems, one in each of three user categories: commercial aviation, high-performance general aviation, and low-performance general aviation.

The model itself is an expected value model which has been programmed in FORTRAN IV + for evaluations using a Digital Equipment Corporation PDP-11/34 minicomputer. The model computes the expected acquisition, installation, and logistic support costs by year and cumulatively for each system. The program is designed for flexibility so that data changes can be readily implemented, sensitivity analyses performed, or additional data outputs obtained.

2. PROGRAM FEATURES

The MLS ALCCM implementation consists of a common main program, called LCCOST, and seven subroutines, each designed to perform a specific function within the model. The seven routines and their functions are:

(1) COSACQ - Calculates the cost of acquisition of the MLS avionics by year and cumulative.

(2) COSINS - Calculates the cost of installation of the MLS avionics by year and cumulative.

(3) COSLOG - Calculates the nonrecurring (investment) and recurring (operation and maintenance) costs of the MLS systems throughout their life cycle.

(4) TOTCUM - Determines the total equipment costs incurred each year and cumulative.

(5) PERGAC - Determines the annual cost per aircraft owner, as well as the annual cost per aircraft for the avionics equipment.

(6) DISCNT - Discounts constant dollars figures according to the guidelines set forth by the FAA.

(7) OUTTAB - Prints in table form the results of all the above computations.

Six input data files were used in exercising the MLS ALCCM; one system file for each of the three configurations to be evaluated, and one user file for each of the three user communities. The system and the user file name, the discount rate, and the base year for discounting are specified at the beginning of the program's exercise from the teletype terminal keyboard. The program then calls the designated files and reads them to obtain the specific data parameters used in the evaluation.

The specific outputs of the model, as dictated by the OUTTAB module, are:

(1) The total acquisition cost for the specified user category and designated system by year and cumulative.

(2) The total installation cost for the specified user category and system by year and cumulative.

(3) The total nonrecurring logistic support cost for the specified user category and system by year.

(4) The total recurring logistic support cost for the specified user category and system by year.

(5) The total logistic support cost for the specified user category and system by year and cumulative.

(6) The total cost for the specified user category and system by year and cumulative.

(7) The detailed cost element breakdowns of the nonrecurring, recurring, and total logistic support costs for the specified user category and system by year.

(8) The cost per year to the specified aircraft owner and the cost per aircraft per year.

3. MODEL FORMULATION

The following describes the mathematical formulation of the MLS ALCCM which has been implemented into the program LCCOST. The model computes on a yearly and cumulative basis the acquisition, installation, logistic support costs, and their totals for a given MLS system concept in the time period 1989-2009. The parameter definitions used in the model are presented after each set of formulas as well as in Appendix I.

3.1 Acquisition Costs

The acquisition costs are determined by the number of MLS systems purchased by the user community each year and the average unit cost of the systems during the year (reflecting learning curves and amortization costs, if applied). The acquisition costs for year i are given by:

$$ACOS_i = (NAV)\ (CRFT_i)(FUCOS_i) + AMCOS;\ i \leq 2$$

$$= (NAV)\ (CRFT_i)\ (FUCOS_i) \qquad ;\ i > 2$$

where:

$$CRFT_i = NAC_i + NRAC_i$$

The cumulative acquisition cost is simply:

$$TCOSA_i = \sum_{j=1}^{i} ACOS_i$$

Variables are:

NAV = average no. of avionics systems per aircraft

$FUCOS_i$ = average system cost in year i = program internal

AMCOS = amortization cost

NAC_i = no. of new aircraft in year i

$NRAC_i$ = no. of aircraft retrofitted in year i

3.2 Installation Costs

The installation cost in the i'th year is determined by the number of MLS units installed in new aircraft or retrofitted into existing aircraft that year multiplied by the appropriate per unit installation rate. The resultant installation cost equation is given by:

$$ICOS_i = (NAV)[(NRAC_i)(RICOS) + (NAC_i)(INCOS)]$$

The cumulative installation cost is given by:

$$TCOSI_i = \sum_{j=1}^{i} ICOS_i$$

Variables are:

NAV = average no. of avionics systems per aircraft

$NRAC_i$ = no. of aircraft to be retrofitted in year i

RICOS = retrofit installation cost per system

NAC_i = no. of new aircraft in year i

INCOS = new aircraft installation cost per system

3.3 Logistic Support Costs

The logistic support cost is considered to be composed of the sum of eight cost elements, each having a nonrecurring (investment) and recurring (operating and maintenance) cost component. Hence, the logistic support cost in the i'th year is given by:

$$LCOS_i = \sum_{j=1}^{8} [NRCOS_{i,j} + RLCOS_{i,j}],$$

with $NRCOS_{i,j}$ representing the nonrecurring costs and $RLCOS_{i,j}$ representing the recurring costs. Similarly, the cumulative nonrecurring, recurring, and logistic support costs for year i are given by:

$$TCOSN_i = \sum_{j=1}^{i} TNRCOS_j$$

$$TCOSR_i = \sum_{j=1}^{i} TRLCOS_j$$

$$TCOSL_i = \sum_{j=1}^{i} LCOS_j$$

where:

$$TNRCOS_j = \sum_{k=1}^{8} NRCOS_{j,k}$$

$$TRLCOS_j = \sum_{k=1}^{8} RLCOS_{j,k}$$

The following paragraphs present the methodology for determining the individual cost elements and their components.

3.3.1 Initial and Replacement Spares

This cost element consists of the expenses associated with the procurement of the spares inventory. The nonrecurring component is the expenditure in the i'th year to purchase the spares required to satisfy the expected demand with a given level of spares sufficiency. In determining the nonrecurring costs, assumptions which should be noted are:

(1) When dictated by the sparing philosophy, a minimum of one spare of each type of the principal modules, or LRUs and sub-modules, or SRUs, is assumed for each base.

(2) When dictated by the sparing philosophy, a minimum of one spare of each type LRU and SRU is assumed for each depot.

The recurring spares cost represents the cost of purchasing additional spares to replace those lost to the logistic system through condemnation and attrition.

The resultant components are given by:

$$NRCOS_{i,1} = \sum_{j=1}^{NLRU} \left[(NLSPRS_{i,j})(LUCOS_j) + \sum_{k=1}^{NSRU_j} (NSSPRS_{i,j,k})(SUCOS_{j,k}) \right]$$

where, for nonrepairable LRUs:

$$NLSPRS_{i,j} = INT[(NOB_i)(YDUM+SUF(2)\sqrt{YDUM})] + INT[(NOD_i)(ZDUM+SUF(2)\sqrt{ZDUM})] + INT(TDUM) + INT(SDUM) - NSPRL_j$$

$$YDUM = (TFAV_i)(FBLRU)(BSOBL)(ILRUB_j)/((NOB_i)(LMTBF_j))$$

$$ZDUM = (TFAV_i)(FBLRU)(BSODL)(ILRUD_j)/((NOD_i)(LMTBF_j))$$

$$TDUM = (TFAV_i)(FBLRU)(OSBL)(ILRUB_j)/LMTBF_j$$

$$SDUM = (TFAV_i)(FBLRU)(OSDL)(ILRUD_j)/LMTBF_j$$

and:

$$FBLRU = BIT + (1-BIT)(RTSS)$$

$$TFAV_i = (12)\ (AFHR)(NS_i)$$

$$NS_i = \sum_{j=1}^{i} (NAV)(CRFT_j)$$

where, for repairable LRUs:

$$NLRSPRS_{i,j} = \{\{Max[INT[(NOB_i)(YDUM + SUF(2)\sqrt{YDUM})], (MINB)(NOB_i)/LCOML_j]\}(ILRUB_j) + \{Max[INT[(NOD_i)(ZDUM + SUF(2)\sqrt{ZDUM})], (MINB)(NOD_i)/LCOML_j]\}(ILRUD_j)] - NSPRL_j$$

and:

$$YDUM = (TFAV_i)(FBLRU)(RTS_j)(BMT)/[(NOB_j)(LMTBF_j)]$$

$$ZDUM = (TFAV_i)(FBLRU)(1-RTS_j)(DMT)/[(NOD_i)(LMTBF_j)]$$

where, for nonrepairable SRUs:

$$NSSPRS_{i,j,k} = INT[(NOB_i)(XDUM + SUF(3)\sqrt{XDUM})]$$
$$+ INT[(NOD_i)(XDUM+SUF(3)\sqrt{YDUM})]$$
$$+ INT(WDUM)+INT(TDUM)-NSPRB_{j,k}$$

and:

$$XDUM = (TFAV_i)(FBLRU)(RTS_j)(BSOB)(ISRUB_{j,k})/[(NOB_i)(SMTBF_{j,k})]$$

$$YDUM = (TFAV_i)(FBLRU)(1-RTS_j)(BSOD)(ISRUD_{j,k})/[(NOD_i)(SMTBF_{j,k})]$$

$$WDUM = (TFAV_i)(FBLRU)(RTS_j)(OSB)(ISRUB_{j,k})/SMTBF_{j,k}$$

$$TDUM = (TFAV_i)(FBLRU)(1-RTS_j)(OSD)(ISRUD_{j,k})/SMTBF_{j,k}$$

where, for repairable SRUs:

$$NSSPRS_{i,j,k} = \{\{Max[INT[(NOB_i)(XDUM + SUF(3)\sqrt{XDUM})],$$
$$(XMINB)(NOB_i)/LCOMS_{j,k}]\}(ISRUB_{j,k})$$
$$+\{Max[INT[(NOD_i)(YDUM+SUF(3)\sqrt{YDUM})],$$
$$(XMINB)(NOD_i)/LCOMS_{j,k}]\}\}(ISRUD_{j,k})\}-NSPRB_{j,k}$$

$$RLCOS_{i,1} = \sum_{j=1}^{NLRU} [(RLSPRS_{i,j})(LUCOS_j) + \sum_{k=1}^{NSRU_j} (RSSPRS_{j,k})(SUCOS_{j,k})]$$

where:

$$RLSPRS_{i,j} = INT[(TFAV_i)(COND_j)(1-ITWL_j)/LMTBF_j]$$

$$RSSPRS_{i,j,k} = INT[(TFAV_i)(CONDB_{j,k})(1-ITWS_{j,k})/SMTBF_{j,k}](1-ITWL_j)$$

Variables are:

NOB_i = no. of bases in year i

NOD_i = no. of depots in year i

SUF(2) = LRU spares sufficiency factor

$NSPRL_j$ = no. LRU_j spares purchased prior to year i

BSOBL = base LRU stocking objective

BSODL = depot LRU stocking objective

OSBL = average LRU order/ship time, base

OSDL = average LRU order/ship time, depot

$ILRUB_j$ = base sparing flag for LRU_j

$ILRUD_j$ = depot sparing flag for LRU_j

BIT = fraction of failures isolated to LRU by Built-In Test Equipment

RTSS = fraction of failures isolated to LRU level at base without using BITE

AFHR = average monthly flight operating hours

NS_i = no. of systems in operation in year i = program internal

NAV = average no. of avionics units per aircraft

[illegible]$_i$ = no. of aircraft receiving avionics in year i

NLRU = no. of LRUs in system

$LUCOS_j$ = unit cost of jth LRU = program internal

$NSRU_j$ = no. of SRUs in j'th LRU

$SUCOS_{j,k}$ = unit cost of k'th SRU in j'th LRU

MINB = minimum no. of each type LRU spare

$LCOML_j$ = no. of avionics unit types to which LRU_j is common

RTS_j = fraction of LRU_j failures isolated to SRU at base

BMT = base turnaround time

$LMTBF_j$ = mean time between failures of j'th LRU = program internal

DMT = depot turnaround time

SUF(3) = SRU spares sufficiency factor

$NSPRB_{j,k}$ = no. of $SRU_{j,k}$ spares purchased prior to year i

BSOB = base SRU stocking objective

$SMTBF_{j,k}$ = mean time between failures of $SRU_{j,k}$

BSOD = depot SRU stocking objective

OSB = average SRU order/ship time, base

OSD = average SRU order/ship time, depot

$ISRUB_{j,k}$ = base sparing flag for $SRU_{j,k}$

$ISRUD_{j,k}$ = depot sparing flag for $SRU_{j,k}$

XMINB = minimum no. of each type SRU spare

$LCOMS_{j,k}$ = no. of LRUs to which $SRU_{j,k}$ is common

$COND_j$ = fraction of LRU_j failures that are condemned

$CONDB_{j,k}$ = fraction of $SRU_{j,k}$ failures that are condemned

$ITWL_j$ = repair/throw-away flag for LRU_j

$ITWS_{j,k}$ = repair/throw-away flag for $SRU_{j,k}$

3.3.2 On-Aircraft Maintenance

This cost element represents the expected expenditures in performing on-aircraft corrective maintenance. This element contains only a recurring cost component, i.e., $NRCOS_{i,2} = 0$, and represents the costs associated with remove and replace actions, as well as preventive maintenance actions. The cost is determined as follows:

$$RLCOS_{i,2} = \sum_{j=1}^{NLRU} [(TFAV_i)(RMHB_j)/LMTBF_j]+(NS_i)(FPM)(PMMH)\}(BLR)$$

where:

$$TFAV_i = (12)(AFHR)(NS_i)$$

Variables are:

NLRU = no. of LRUs in avionics system

$RMHB_j$ = average time to remove and replace j'th LRU

$LMTBF_j$ = mean time between failures of j'th LRU = program internal

NS_i = no. of systems in operation in year i

FPM = frequency of preventive maintenance

PMMH = average time required to complete preventive maintenance actions

AFHR = average monthly flight operating hours

3.3.3 Off-Aircraft Maintenance

The expected material, labor, shipping, and documentation costs associated with performing corrective maintenance at the base and depot locations are represented by this cost element. Like the on-aircraft maintenance cost element, off-aircraft maintenance consists of a recurring cost component only, i.e., $NRCOS_{i,3} = 0$. This component is determined by:

$$RCOS_{i,3} = TMAT_i + TLABOR_i + TSHIP_i + BDMTD_i + DDMTD_i$$

where:

$$TMAT_i = (TFAV_i)[\sum_{j=1}^{NLRU} [((FBLRU)(RTS_j)(RTLB_j)(BMC_j) +$$

$$((FBLRU)(RTS_j)(1-RTLB_j) + (FBLRU)(1-RTS_j))(DMC_j))/LMTBF_j$$

$$+ \sum_{k=1}^{NSRU_j} [(FBLRU)(RTSB_{j,k})(BMCS_{j,k})(RTS_j) + (FBLRU)[(RTS_j)$$

$$(1-RTSB_{j,k}) + (1-RTS_j)](DMCS_{j,k})]/SMTBF_{j,k}]]$$

$$TLABOR_i = (TFAV_i)[\sum_{j=1}^{NLRU} [((FBLRU)(RTS_j)(RTLB_j')(LMTTR_j)$$

$$(1-ITWL_j)(BLR)/LMTBF_j) + \sum_{k=1}^{NSRU_j} [(FBLRU)(RTS_j)(RTSB_{j,k})$$

$$(SMTTR_{j,k})(BLR))+((FBLRU)[(RTS_j)(1-RTSB_{j,k})+(1-RTS_j)]$$

$$(SMTTR_{j,k})(DLR))(1-ITWS_{j,k})/SMTBF_{j,k}]]]$$

$$TSHIP_i = (PACK)(TFAV_i)[XLTTR_i+XSTTR_i)[(2)(YMIL)(SSHC)$$

$$+(XMIL)(SHC)]+(XLSHP_i)]$$

and:

$$XLTTR_i = \sum_{j=1}^{NLRU} (WT_j)(COND_j)/LMTBF_j$$

$$XSTTR_i = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_j} (WTB_{j,k})(CONDB_{j,k})/SMTBF_{j,k}$$

$$XLSHP_i = \sum_{j=1}^{NLRU} [(WT_j)[(FBLRU)[(1-RTS_j)+(RTS_j)(1-RTLB_j)]$$

$$(2)(YMIL)(SSHC)(1-ITWL_j)+[(FBLRU)(1-RTS_j)$$

$$((YMIL)(SSHC)+(XMIL)(SHC))(ITWL_j)]]/LMTBF_j]$$

$$XSSHP_i = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_j} [(WTB_{j,k})[(FBLRU)(RTS_j)(1-RTSB_{j,k})(2)$$

$$(YMIL)(SSHC)(1-ITWS_{j,k})+(FBLRU)(RTS_j)((YMIL)(SSHC)+$$

$$(XMIL)(SHC))(ITWS_{j,k})]/SMTBF_{j,k}]$$

$$TFAV_i = (12)(AFHR)(NS_i)$$

$$FBLRU = BIT+(1-BIT)(RTSS)$$

where:

$$BDMTD_i = (BDOC + (LRUT + SRUT)(TFR))(TFAV_i)(BLR)$$

$$DDMTD_i = (DDOC + (LRUT + SRUT)(TFR))(TFAV_i)(DLR)$$

and:

$$BDOC = (ONAC + OFAC + STR)/UMTBF$$

$$DDOC = (OFAC + STR)/UMTBF$$

$$LRUT = \sum_{j=1}^{NLRU} (FBLRU)(1-RTS_j)/LMTBF_j$$

$$SRUT = \sum_{j=1}^{NLRU} \sum_{k=1}^{NSRU_j} (FBLRU)(RTS_j)(1-RTSB_{j,k})/SMTBF_{j,k}$$

Variables are:

$NLRU$ = no. of LRUs in avionics system

RTS_j = fraction of LRU_j failures isolated to SRU at base

$RTLB_j$ = fraction of repairable LRU_j failures repaired at base

BMC_j = average base materials cost per maintenance action on j'th LRU

DMC_j = average depot materials cost per maintenance action on j'th LRU

$LMTBF_j$ = mean time between failures of j'th LRU = program internal

$NSRU_j$ = no. of SRUs in j'th LRU

$RTSB_{j,k}$ = fraction of repairable $SRU_{j,k}$ repaired at base

$BMCS_{j,k}$ = average base materials cost per maintenance action on $SRU_{j,k}$

$DMCS_{j,k}$ = average depot materials cost per maintenance action on $SRU_{j,k}$

$SMTBF_{j,k}$ = mean time between failures of $SRU_{j,k}$

$LMTTR_j$ = mean time to repair j'th LRU

$ITWL_j$ = repair/throw-away flag for j'th LRU

BLR = base labor rate

$SMTTR_{j,k}$ = mean time to repair $SRU_{j,k}$

DLR = depot labor rate

$ITWS_{j,k}$ = repair/throw-away flag for $SRU_{j,k}$

$PACK$ = packaging factor = packed wt./unpacked wt.

$YMIL$ = average no. of shipping zones between base and depot

$SSHC$ = shipping rate per lb between base and depot

$XMIL$ = average no. of shipping zones to first destination

SHC = shipping rate per lb to first destination

WT_j = weight of j'th LRU

$COND_j$ = fraction of failed LRU_j that are condemned

$WTB_{j,k}$ = weight of $SRU_{j,k}$

$CONDB_{j,k}$ = fraction of failed $SRU_{j,k}$ that are condemned

AFHR = average monthly flight operating hours

NS_i = no. of systems in operation in year i

BIT = fraction of failures isolated to LRU by Built-In Test Equipment

RTSS = fraction of failures isolated to LRU at base without using BITE

ONAC = time required to complete on-aircraft maintenance records

OFAC = time required to complete off-aircraft maintenance records

STR = time required to complete supply transaction records

TFR = time required to complete transportation forms

UMTBF = mean time between system failures = program internal

3.3.4 Inventory Entry and Supply Management

This cost element represents the cost associated with introducing and maintaining new coded supply items in the user inventory and the management cost of maintaining a supply inventory for all of the coded items that are stocked at the repair sites. The first year's inventory entry cost is treated as a nonrecurring cost ($NRCOS_{i,4}$); the supply management cost is treated as a recurring cost throughout ($RLCOS_{i,4}$). The resultant components are given by:

$$NRCOS_{i,4} = (IAMC)(NIC)(TIC)(NICB);\ i = 1$$
$$= 0 \qquad ;\ i \neq 1$$

where:

$$NICB = 1;\ FRAV \neq 0.$$
$$= 0;\ FRAV = 0.$$

and:

$$RLCOS_{i,4} = [(NOB_i)(NOIB)(HOLDB)+(NOD_i)(NOID)(HOLDD)](NICB);\ i = 1$$
$$= [(IAMC)(NIC)(TIC)+(NOB_i)(NOIB)(HOLDB)+(NOD_i)(NOID)(HOLDD)]$$
$$(NICB);\ i \neq 1$$

Variables are:

IAMC = cost of introducing each new coded item

NIC = fraction of inventory coded items that are new

TIC = total no. of inventory coded items

NOB_i = no. of bases in year i

NOIB = no. of different item types stocked at base

HOLDB = average annual holding cost per item type, base

NOD_i = no. of depots in year i

NOID = no. of different item types stocked at depot

HOLDD = average annual holding cost per item type, depot

3.3.5 Special Support Equipment

Included in this cost element are the nonrecurring costs of purchasing special test equipment ($NRCOS_{i,5}$) and the recurring costs of operating that equipment ($RLCOS_{i,5}$). It is assumed in the model that the test equipment is unique to the system being evaluated. It is further assumed that there will be a minimum of one of each type of support equipment at each base and depot facility. The nonrecurring and recurring costs of special support equipment in the i'th year, assuming that $NSEB_m$ and $NSED_m$ units of the m'th equipment type have been purchased prior to year i at the base and depot level, are given by:

$$NRCOS_{i,5} = NNSEB_i + NNSED_i$$

where:

$$NNSEB_i = \sum_{m=1}^{JSEB} [Max\{INT[(PFAV_i)(TBMH)(UTILB_m)/((UMTBF)$$

$$(AVALB_m)(BETA))],(MINSEB)(NOB_i)/LCOMB_m\} - NSEB_m]$$

$$(USECOB_m)$$

$$NNSED_i = \sum_{m=1}^{JSED} [Max\{INT[(PFAV_i)(TDMH)(UTILD_m)/((UMTBF)$$

$$(AVALD_m)(DETA))],(MINSED)(NOD_i)/LCOMD_m\}$$

$$- NSED_m](USECOD_m)$$

$$PFAV_i = (12)(PFHR)(NS_i)$$

$$TBMH = \sum_{m=1}^{NLRU} BMH_m$$

$$TDMH = \sum_{m=1}^{NLRU} DMH_m$$

and:

$$RLCOS_{i,5} = RNSEB_i + RNSED_i$$

where:

$$RNSEB_i = \sum_{m=1}^{JSEB} [Max\{(PFAV_i)(TBMH)(UTILB_m)(SECOB)/((UMTBF)$$

$$(AVALB_m)(BETA)),(MSEBO)(NSEB_m)\}]$$

$$RNSED_i = \sum_{m=1}^{JSED} [Max\{(PFAV_i)(TDMH)(UTILD_m)(SECOD)/((UMTBF)$$

$$(AVALD_m)(DETA)),(MSEDO)(NSED_m)\}]$$

Variables are:

PFHR = peak monthly flight operating hours

TBMH = total average base labor hours required to isolate LRU failure to SRU level

BMH_m = average base labor hours required to isolate failure in LRU_m to SRU level

$UTILB_m$ = utilization rate of m'th type support equipment

UMTBF = mean time between system failures

BETA = base support equipment hours available per month

$AVALB_m$ = availability of m'th type support equipment, base

MINSEB = minimum no. of each type support equipment, base

$LCOMB_m$ = no. avionics unit types to which m'th type base support equipment is common

$USECOB_m$ = unit cost of m'th type base support equipment

JSEB = no. of different types base support equipment

TDMH = total average depot labor hours required to isolate LRU failure to SRU level

DMH_j = average depot labor hours required to isolate failure in LRU_j to SRU level

NOB_i = no. of bases in year i

JSED = no. of different types depot support equipment

NOD_i = no. of depots in year i

$UTILD_m$ = utilization rate of m'th type depot support equipment

DETA = depot support equipment hours available per month

$AVALD_m$ = availability m'th type depot support equipment

MINSED = minimum no. of each type depot support equipment

$LCOMD_m$ = no. of avionics unit types to which m'th type depot support equipment is common

$USECOD_m$ = unit cost of m'th type depot support equipment

NS_i = no. of systems in operation in year i

SECOB = support equipment operating cost, base

MSEBO = minimum annual support equipment operating cost, base

SECOD = support equipment operating cost, depot

MSEDO = minimum annual support equipment operating cost, depot

3.3.6 Training

The training cost consists of the specialized maintenance training required to meet the expected corrective maintenance demands ($NRCOS_{i,6}$) and the recurrent cost of additional specialized training resulting from the turnover of repair personnel ($RLCOS_{i,6}$). It is assumed that a minimum of one person per maintenance site will receive training. The training costs incurred in year i, then, assuming that NPERB base personnel and NPERD depot personnel have been trained prior to year i, are:

$$NRCOS_{i,6} = (NBPER_i)(TCOSB)+(NDPER_i)(TCOSD)$$

where:

$$NBPER_i = Max\{INT[(TFAV_i)(AMHB)/((PMB)(PRODB)(UMTBF))], (MINBP)(NOB_i)\} - NPERB$$

$$NDPER_i = Max\{INT[(TFAV_i)(AMHD)/((PMD)(PRODD)(UMTBF))], (MINDP)(NOD_i)\} - NPERD$$

$$TFAV_i = (12)(AFHR)(NS_i)$$

$$AMHB = (UMTBF)\{[(1-BIT)(BMHS)/UMTBF]+(FBLRU)\sum_{j=1}^{NLRU}[[(BMH_j)(RTS_j) + (RTLB_j)(LMTTR_j)]/LMTBF_j+(RTS_j)\sum_{k=1}^{NSRU}[(RTSB_{j,k})(SMTTR_{j,k})/SMTBF_{j,k}]]\}$$

$$AMHD = (UMTBF)\{[(1-BIT)(1-RTSS)(DMHS)/UMTBF] + \sum_{j=1}^{NLRU}[[[(1-BIT)(1-RTSS)+(FBLRU)(1-RTS_j)](DMH_j)+ (FBLRU)[(1-RTLB_j)(LMTTR_j)]]/LMTBF_j + \sum_{k=1}^{NSRU_j}[[(1-BIT)(1-RTSS) +(FBLRU)[(1-RTS_j)+(RTS_j)(1-RTSB_{j,k})]](SMTTR_{j,k})/(SMTBF_{j,k})]]\}$$

and:

$$RLCOS_{i,6} = (NPERB)(TCOSB)(TRB)+(NPERD)(TCOSD)(TRD)$$

Variables are:

TCOSB = training cost per base repair person

TCOSD = training cost per depot repair person

AMHB = average labor-hours per maintenance action, base = program internal

UMTBF = mean time between system failures = program internal

BIT = fraction of failures isolated to LRU by Built-In Test Equipment

BMHS = average labor-hours to isolate failure to LRU at base

NLRU = no. of LRUs in avionics system

BMH_j = average labor-hours to isolate failures in j'th LRU to SRU level at base

RTS_j = fraction LRU_j failures isolated to SRU at base

$RTLB_j$ = fraction of repairable LRU_j repaired at base

$LMTTR_j$ = mean time to repair LRU_j

$LMTBF_j$ = mean time between failures j'th LRU = program internal

$NSRU_j$ = no. of SRUs in j'th LRU

$RTSB_{j,k}$ = fraction of repairable $SRU_{j,k}$ repaired at base

$SMTTR_{j,k}$ = mean time to repair $SRU_{j,k}$

$SMTBF_{j,k}$ = mean time between failures of $SRU_{j,k}$

PMB = available hours per year per repair person, base

PRODB = productivity of base repair personnel

MINBP = minimum no. repair personnel per base

NOB_i = no. of bases in year i

AMHD = average labor-hours per maintenance action, depot = program internal

RTSS = fraction of failures isolated to LRU at base

DMHS = average labor-hours to isolate failure to LRU at depot

DMH_j = average labor-hours to isolate failures in j'th LRU to SRU level at depot

PMD = available hours per year per repair person depot

PRODD = productivity of depot repair personnel

MINDP = minimum no. repair personnel per depot

NOD_i = no. of depots in year i

AFHR = average monthly flight operating hours

NS_i = no. of systems in operation in year i

TRB = turnover rate, base repair personnel

TRD = turnover rate, depot repair personnel

3.3.7 Data Management and Technical Documentation

The data management and technical documentation element consists only of the nonrecurring cost ($NRCOS_{i,7}$) associated with the preparation of base and depot level documentation ($RLCOS_{i,7} = 0$). These costs are given by the equation:

$$NRCOS_{i,7} = (CPP)\left[(NPDB)(NNBAS_i)+(NPDD)(NNDEP_i)\right]$$

where:

$$NNBAS_i = NOB_i \qquad ; i = 1$$
$$= NOB_i - NOB_{(i-1)}; \quad i \neq 1$$

$$NNDEP_i = NOD_i \qquad ; i = 1$$
$$= NOD_i - NOD_{(i-1)}; \quad i \neq 1$$

Variables are:

CPP = cost per page, original technical documentation

$NPBD$ = no. of pages base level documentation

$NPDD$ = no. of pages depot level documentation

NOB_i = no. of bases in year i

NOD_i = no. of depots in year i

3.3.8 Facilities

The facilities costs are considered to consist of the recurring operating costs of the repair facilities (e.g., space rent, electricity, general tools, etc.). It is assumed that no new support facilities will be required for the system; hence, $NRCOS_{i,8} = 0$. The recurring cost ($RLCOS_{i,8}$) is then given by:

$$RLCOS_{i,8} = (FOCB)(NOB_i) + (FOCD)(NOD_i)$$

Variables are:

$FOCB$ = annual base facilities cost attributable to system being analyzed

$FOCD$ = annual depot facilities cost attributable to system being analyzed

NOB_i = number of base maintenance sites, year i

NOD_i = number of depot maintenance sites, year i

APPENDIX H

LIFE-CYCLE-COST MODEL
FOR AIRBORNE EQUIPMENT

```
C                          PROGRAM LCCOST
C
C     THE PROGRAM LCCOST DETERMINES THE TOTAL LIFE CYCLE COST OF
C     SPECIFIED AVIONICS UNIT(S). DATA IS INPUT TO THE PROGRAM
C     BY MEANS OF THE USER TERMINAL, A SYSTEM FILE (SFILE), AND
C     A USER FILE (UFILE). THE PROGRAM USES THE DATA TO DETERMINE
C     ANNUAL ACQUISITION COSTS, INSTALLATION COSTS, AND LOGISTIC
C     SUPPORT COSTS, WHICH ARE THEN OUTPUT IN TABULAR FORM IN
C     BOTH CONSTANT AND DISCOUNTED DOLLARS.
C
      PROGRAM LCCOST
C
C    *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
      COMMON/CAT/CLCC, TNRCAT(9), TRLCAT(9), TPROG(25), CPROG(25)
      COMMON/INSTAL/ICOS(25), TCOSI(25)
      COMMON/LOGIST/NRCOS(25,8), RLCOS(25,8), TCOSL(25), TLLCOS(25),
     1              TNRCOS(25), TRLCOS(25), TCOSN(25), TCOSR(25)
      COMMON/MISCLO/ NBAS(25), NDEF(25), UMTBF, UCOS
      COMMON/SYSTEM/BMC(20),BMCS(20,20),COND(20),CONDB(20,20),DMC(20),
     1              DMCS(20,20),ITWL(20),ITWS(20,20),LCOML(20),
     2              LCOMS(20,20),LMTBF(20),NLRU,NSRU(20),RMHB(20),
     3              RTS(20),RTSB(20,20),SMTBF(20,20),ILRUB(20),ILRUD(20)
     4              ,ISRUB(20,20),ISRUD(20,20)
      COMMON/VIONIX/AMCOS, FRAV, FUCOS, INCOS, LUCOS(20), NAV,
     1              PQTY, RICOS, SUCOS(20,20), WT(20), WTB(20,20), XLRN,
     2              BMH(20), DMH(20), RTLB(20), LMTTR(20), SMTTR(20,20)
      COMMON/NAMES/SNAME, UNAME
C
C    *DECLARE VARIABLES AND DATA
C
      INTEGER BEGYR,ENDYR,ITWL,ITWS,LCOML,LCOMS,NBAS,NDEF,NLRU,NNB,NND
      INTEGER NOBAS,NODEF,NREYR,NSRU,NUM,NYRS,YEAR,YR,BASEYR
      REAL AMCOS,BMC,BMCS,COND,CONDB,DIST,DMC,DMCS,FRAV,FUCOS,ICOS
      REAL INCOS,LMTBF,LUCOS,NAC,NNAC(25),NRAC,PQTY,RICOS,RMHB
      REAL RTS,RTSB,SMTBF,SUCOS,TNRAC,UMTBF,WT,WTB,XDIS,XLRN,LMTTR,NRCOS
      REAL LDIST,SDIST,KFAC
      LOGICAL*1 ANS, SNAME(65), UNAME(35), SFILE(16), UFILE(16)
      DATA SFILE/'S','Y','0',':',6*'X','.','D','A','T',0,0/
      DATA UFILE/'S','Y','0',':',6*'Y','.','D','A','T',0,0/
      DATA UMTBF/0.0/, SNAME/65*0/, UNAME/35*0/
C
C    *INITIALIZE TERMINAL INPUT VARIABLES
C
10    WRITE(1,*) '------AVIONICS LIFE CYCLE COST EVALUATION------'
      WRITE(1,*) ' '
      WRITE(1,*) ' '
20    WRITE(1,*) 'SYSTEM FILE NAME?'
      READ(1,1002) (SFILE(I), I = 5, 10)
      WRITE(1,*) ' '
```

```
30    WRITE(1,*) 'USER FILE NAME?'
      READ(1,1002) (UFILE(I), I = 5,10)
      WRITE(1,*) '  '
      WRITE(1,*) 'DISCOUNT RATE?'
      READ(1,1003) XDIS
      WRITE(1,*) '  '
      WRITE(1,*) 'BASE YEAR FOR DISCOUNTING PURPOSES? (E.G. 1980)'
      READ(1,1013) BASEYR
      WRITE(1,*) '  '
      WRITE(1,*) 'VALUE OF K FACTOR (FOR MTBF SENSITIVITY ANALYSIS)?'
      WRITE(1,*) '(NOTE:ENTER 1.0 IF YOU DO NOT WISH TO PERFORM THE'
      WRITE(1,*) 'SENSITIVITY ANALYSIS.)'
      READ(1,1003) KFAC
      WRITE(1,*) '  '
C
C     *READ DATA FROM SYSTEM AND USER FILES
C
      OPEN(UNIT=2,NAME=SFILE,TYPE='OLD',READONLY,ERR=901)
      OPEN(UNIT=3,NAME=UFILE,TYPE='OLD',READONLY,ERR=902)
40    READ(2,1004) (SNAME(I), I = 1, 65)
      READ(3,1004) (UNAME(I), I = 1, 35)
C
C     *INITIALIZE YEAR, NNAC, NRAC, NBAS, AND NDEP ARRAYS BY READING
C     *APPROPRIATE DISK FILE
C
      READ(3,1009) NYRS
C
      DO 50 I = 1, NYRS
        READ(3,1006) YEAR(I),NNAC(I),NRAC(I),NBAS(I),NDEP(I)
50    CONTINUE
C
      READ(2,1010) POTY,AMCOS
      READ(3,1005) INCOS,RICOS,DIST,LDIST,SDIST
      READ(3,1012) NAV,FRAV,XLRN
C
C     *DETERMINE NUMBER OF NEW AIRCRAFT IN AVIONICS FLEET IN YEAR I
C
      DO 55 I = 1, NYRS
        NAC(I) = AINT(FRAV*NNAC(I))
55    CONTINUE
C
C      *READ LRU AND SRU DATA
C
        UCOS = 0.0
        READ(2,1006) NLRU
        DO 70 I = 1, NLRU
          READ(2,1004)
          READ(2,1011) ILRUB(I),ILRUD(I),ITWL(I),LCOML(I)
          READ(2,1008) WT(I),RTS(I),COND(I),NSRU(I)
          READ(2,1005) RMHB(I),BMC(I),DMC(I)
          READ(2,1005) BMH(I),DMH(I),RTLB(I),LMTTR(I)
          LMTBF(I) = 0.0
```

```
            LUCOS(I) = 0.0
            IF (NSRU(I) .EQ. 0) GO TO 60
            DO 60 J = 1, NSRU(I)
              READ(2,1004)
              READ(2,1007) SUCOS(I,J),SMTBF(I,J),ITWS(I,J),LCOMS(I,J)
              READ(2,1008) WTB(I,J),RTSB(I,J),CONDB(I,J),ISRUB(I,J)
              READ(2,1009) ISRUD(I,J),BMCS(I,J),DMCS(I,J),SMTTR(I,J)
              LUCOS(I) = LUCOS(I) + SUCOS(I,J)
              IF (SMTBF(I,J) .NE. 0.) LMTBF(I) = LMTBF(I)+(1./SMTBF(I,J))
60          CONTINUE
            IF (LMTBF(I) .NE. 0.) LMTBF(I) = 1./LMTBF(I)
70        CONTINUE
C
C       *CALCULATE MTBF AND UNIT COST FOR SYSTEM
C
          DO 90 I = 1, NLRU
            IF (LMTBF(I) .NE. 0.) UMTBF = UMTBF + 1./LMTBF(I)
            UCOS = UCOS + LUCOS(I)
90        CONTINUE
          UMTBF = (1./UMTBF)/KFAC
C
C       *CALCULATE COST OF REPLACEMENT LRUS AND SRUS
C
          DO 95 I = 1,NLRU
            LUCOS(I) = LUCOS(I)*(1 + LDIST)
            LMTBF(I) = LMTBF(I)/KFAC
            BMC(I) = BMC(I)*KFAC
            DMC(I) = DMC(I)*KFAC
            DO 92 J = 1,NSRU(I)
              SUCOS(I,J) = SUCOS(I,J)*(1 + SDIST)
              SMTBF(I,J) = SMTBF(I,J)/KFAC
              BMCS(I,J) = BMCS(I,J)*KFAC
              DMCS(I,J) = DMCS(I,J)*KFAC
92          CONTINUE
95        CONTINUE
C
C       *CALCULATE ACQUISITION AND INSTALLATION COSTS
C
          CALL COSACQ(NYRS,UCOS,DIST)
C
C       *CALCULATE LOGISTIC SUPPORT COST OF AVIONICS SYSTEM
C
          CALL COSLOG(NYRS,OWNER)
C
C     *CALCULATE TOTALS FOR LIFE CYCLE
C
        CALL TOTCUM(NYRS)
C
C     *PRINT ANNUAL COST PER OWNER AND PER AIRCRAFT
C
        DSCNT = 0.0
        CALL PERGAC(NYRS,DSCNT)
```

```
C
C     *PRINT ANNUAL LOGISTIC SUPPORT COSTS BY CATEGORY AND TOTAL LIFE
C     *CYCLE COSTS BY YEAR
C
       CALL OUTTAB(NYRS,DSCNT)
C
C     *CALCULATE AND PRINT DISCOUNTED ANNUAL LOGISTIC SUPPORT COSTS
C     *BY CATEGORY AND DISCOUNTED TOTAL LIFE CYCLE COSTS BY YEAR
C
       CALL DISCNT(NYRS,XDIS,BASEYR)
       CALL TOTCUM(NYRS)
       CALL PERGAC(NYRS,XDIS)
       CALL OUTTAB(NYRS,XDIS)
C
C     *CLOSE INPUT FILES
C
       CLOSE(UNIT=2,ERR=903)
       CLOSE(UNIT=3,ERR=904)
C
       GO TO 999
C
C     *ERROR STATEMENTS
C
901    WRITE(1,*) 'ERROR IN OPENING SFILE. PLEASE TRY AGAIN.'
       GO TO 20
C
902    WRITE(1,*) 'ERROR IN OPENING UFILE. PLEASE TRY AGAIN.'
       CLOSE(UNIT=2,ERR=903)
       GO TO 30
C
903    WRITE(1,*) 'ERROR IN CLOSING SFILE. PROGRAM ABORTED.'
       GO TO 999
C
904    WRITE(1,*) 'ERROR IN CLOSING UFILE. PROGRAM ABORTED.'
C
C     *FORMAT STATEMENTS
C
1001   FORMAT(I2)
1002   FORMAT(10A1)
1003   FORMAT(F4.2)
1004   FORMAT(20X,65A1)
1005   FORMAT(10X,F8.2,3(7X,F8.2),7X,F4.2)
1006   FORMAT(10X,I8,7X,F8.0,7X,F8.0,7X,I8,7X,I2)
1007   FORMAT(10X,F8.2,7X,F8.0,2(7X,I8))
1008   FORMAT(10X,2(F8.2,7X),F8.3,7X,I8)
1009   FORMAT(10X,I8,3(7X,F8.2))
1010   FORMAT(10X,F8.2,7X,F8.1,2(7X,F8.2))
1011   FORMAT(10X,4(I8,7X))
1012   FORMAT(10X,I8,7X,F8.2,7X,F8.3)
1013   FORMAT(I4)
C
999    STOP
       END
```

```
C                             SUBROUTINE COSACQ
C
C       THE COSACQ MODULE DETERMINES THE ACQUISITION COST OF THE SPECI-
C       FIED AVIONICS EQUIPMENT FOR EACH YEAR IN THE LIFE CYCLE. ACOS
C       REPRESENTS THE ACQUISITION COSTS INCURRED IN YEAR I: TCOSA REP-
C       RESENTS THE TOTAL ACQUISITION COSTS INCURRED PRIOR TO YEAR I.
C
      SUBROUTINE COSACQ(NYRS,UCOS,DIST)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
      COMMON/INSTAL/ICOS(25), TCOSI(25)
      COMMON/VIONIX/AMCOS, FRAV, FUCOS, INCOS, LUCOS(20), NAV,
     1             PQTY, RICOS, SUCOS(20,20), WT(20), WTB(20,20), XLRN,
     2             BMH(20), DMH(20), RTLB(20), LMTTR(20), SMTTR(20,20)
C
C     *DECLARE VARIABLES
C
      INTEGER NYRS, YEAR
      REAL ACOS,AMCOS,COST,CRFT,FRAV,FUCOS,ICOS,INCOS,LUCOS
      REAL NAC,NPUR,NRAC,RICOS,SUCOS,TCOSA,TCOSI,WT,WTB,LMTTR,LC
      LOGICAL*1 ANS
      DATA ACOS/25*0.0/, TCOSA/25*0.0/
C
C     *INITIAL PRODUCTION COSTS ARE AMORTIZED OVER THE FIRST
C     *TWO YEARS OF PRODUCTION
C
      AMCOS = AMCOS/(2.0*PQTY)
      TQTY = 0.0
      ANS = 'Y'
C
      DO 10 I = 1, NYRS
C
        FUCOS = UCOS
C
C      *COST IS GREATER IF AMORTIZING INITIAL PRODUCTION COSTS
C      *(START-UP COSTS ARE AMORTIZED OVER FIRST TWO YEARS OF
C      *PRODUCTION.)
C
        IF (I .LE. 2) FUCOS = UCOS + AMCOS
C
C      *IS THE LEARNING CURVE TO BE USED?
C
        IF (ANS .NE. 'Y') GO TO 5
        IF (I .NE. 1) GO TO 2
        WRITE(1,*) 'IS THE LEARNING CURVE FACTOR TO BE APPLIED?'
        READ(1,1001) ANS
        WRITE(1,*) ' '
        IF (ANS .NE. 'Y') GO TO 5
C       LC = (TQTY + PQTY/2.)**(ALOG(XLRN)/ALOG(2.0))
```

```
      TQTY = TQTY + PQTY
      FUCOS = FUCOS * LC
C
C     *ADJUST FUCOS TO REFLECT DEALER MARK-UP/-DOWN
C
5     FUCOS = FUCOS*(1 + DIST)
C
C     *DETERMINE NUMBER OF A/C IN WHICH SYSTEM IS TO BE INSTALLED
C     *IN YEAR I
C     *IF (RETROFIT PERIOD IS OVER) NRAC(I) = 0
C
      CRFT(I) = NAC(I) + NRAC(I)
C
C     *CALCULATE NUMBER OF AVIONICS UNITS PURCHASED IN YEAR I
C
      NPUR = NAV*CRFT(I)
C
C     *CALCULATE COST ASSOCIATED WITH ACQUISITION OF AVIONICS UNITS IN
C     *YEAR I
C
      COST = NPUR*FUCOS
C
C     *UPDATE ACQUISITION COSTS FOR YEAR I
C
      ACOS(I) = ACOS(I) + COST
C
C     *CALCULATE INSTALLATION COST FOR FLEET
C
      CALL COSINS(NYRS,I)
C
10    CONTINUE
1001  FORMAT(2A1)
C
      RETURN
      END
```

```
C                              SUBROUTINE COSINS
C
C        THE COSINS MODULE DETERMINES THE INSTALLATION COST OF THE
C        SPECIFIED AVIONICS EQUIPMENT FOR EACH YEAR IN THE LIFE CYCLE.
C        ICOS REPRESENTS THE INSTALLATION COSTS INCURRED IN YEAR I;
C        TCOSI REPRESENTS THE TOTAL INSTALLATION COSTS INCURRED PRIOR
C        TO YEAR I.
C
      SUBROUTINE COSINS(NYRS,I)
C
C    *ESTABLISH COMMON BLOCKS
C
      COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
      COMMON/INSTAL/ICOS(25), TCOSI(25)
      COMMON/VIONIX/AMCOS, FRAV, FUCOS, INCOS, LUCOS(20), NAV,
     1             PQTY, RICOS, SUCOS(20,20), WT(20), WTB(20,20), XLRN,
     2             BMH(20), DMH(20), RTLB(20), LMTTR(20), SMTTR(20,20)
C
C    *DECLARE VARIABLES
C
C
      INTEGER NYRS, YEAR
      REAL AMCOS,COST,CRFT,FRAV,FUCOS,ICOS,INCOS,LUCOS,NAC
      REAL NRAC,PQTY,RICOS,SUCOS,TCOSI,WT,WTB,XLRN,LMTTR
      DATA ICOS/25*0.0/, TCOSI/25*0.0/
C
C    *CALCULATE INSTALLATION COST FOR YEAR I
C
      COST = NAV*(NRAC(I)*RICOS + NAC(I)*INCOS)
C
C    *UPDATE INSTALLATION COSTS FOR YEAR I
C
      ICOS(I) = ICOS(I) + COST
      RETURN
      END
```

```
C                          SUBROUTINE COSLOG
C
C        THE MODULE COSLOG DETERMINES THE RECURRING AND NONRECURRING
C        LOGISTIC SUPPORT COSTS OF THE SPECIFIED AVIONICS EQUIPMENT
C        IN EACH OF EIGHT CATEGORIES: SPARES, ON-AIRCRAFT MAINTENANCE,
C        OFF-AIRCRAFT MAINTENANCE, INVENTORY ENTRY AND SUPPLY MANAGE-
C        MENT, SPECIAL SUPPORT EQUIPMENT, PERSONNEL TRAINING, DATA
C        MANAGEMENT AND TECHNICAL DOCUMENTATION, AND FACILITIES.
C
      SUBROUTINE COSLOG(NYRS)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
      COMMON/LOGIST/NRCOS(25,8), RLCOS(25,8), TCOSL(25), TLLCOS(25),
     1              TNRCOS(25), TRLCOS(25), TCOSN(25), TCOSR(25)
      COMMON/MISCLO/NBAS(25), NDEP(25), UMTBF
      COMMON/SYSTEM/BMC(20),BMCS(20,20).COND(20),CONDR(20,20),DMC(20),
     1              DMCS(20,20),ITWL(20),ITWS(20,20),LCOML(20),
     2              LCOMS(20,20),LMTBF(20),NLRU,NSRU(20),RMHB(20),
     3              RTS(20),RTSB(20,20),SMTBF(20,20),ILRUB(20),ILRUD(20)
     4              ,ISRUB(20,20),ISRUD(20,20)
      COMMON/VIONIX/AMCOS, FRAV, FUCOS, INCOS, LUCOS(20), NAV,
     1              POTY, RICOS, SUCOS(20,20), WT(20), WTB(20,20), XLRN,
     2              BMH(20), DMH(20), RTLB(20), LMTTR(20), SMTTR(20,20)
C
C     *DECLARE VARIABLES
C
      DIMENSION NSPRB(20,20),NSPRL(20),RNSEB(25),RNSED(25),SUF(3),
     1          AVALB(20),AVALD(20),LCOMB(20),LCOMD(20),NBPER(25),
     2          NDPER(25),NSEB(20),NSED(20),USECOB(20),USECOD(20),
     3          UTILB(20),UTILD(20)
      INTEGER XMINB,YEAR
      REAL INCOS,JRTS,LMTBF,LUCOS,MTBFL,MTBFS,NNSEB(25),NRAC,
     1     NNSED(25),NRCOS, IAMC, MSEBO, MSEDO, NBPER, NDPER,
     2     NLSPRS, NPERB, NPERD, NS, NSPRB, NSPRL. NSSPRS, NSEB, NSED,
     3     NSEBY,NSEDY,LRUT,NAC,OWNER(25).LMTTR,LMKUP,SMKUP
      DATA NSPRL/20*0.0/, NRCOS/200*0.0/, RLCOS/200*0.0/
      DATA NSPRB/400*0.0/, RNSEB/25*0.0/, RNSED/25*0.0/
      DATA NNSED/25*0.0/, NNSEB/25*0.0/, OWNER/25*0.0/, NS/0.0/
      DATA NSEB/20*0.0/, NSED/20*0.0/, NBPER/25*0.0/, NDPER/25*0.0/
      DATA TNRCOS/25*0.0/, TRLCOS/25*0.0/, TCOSL/25*0.0/
      DATA TCOSN/25*0.0/, TCOSN/25*0.0/
      DATA LMKUP/1.00/, SMKUP/1.00/
C
C     *READ LOGISTIC SUPPORT DATA
C
      READ(2,1001) BIT,RTSS
      READ(3,1006) BSOBL,BSODL,OSBL,OSDL
      READ(3,1006) BSOB.BSOD,OSB,OSD
      READ(3,1001) FPM,PMMH,CPP.PACK
      READ(3.1001) YMIL,XMIL,SSHC,SHC
```

```
      READ(3,1001) ONAC,OFAC,STR,TFR
      READ(3,1005) IAMC,NIC,TIC
      READ(3,1001) HOLDB,HOLDD
      READ(3,1001) PRODB,PRODD,PMB,PMD
      READ(3,1002) BMT,DMT,NPBD,NPDD
      READ(3,1001) TCOSB,TCOSD,TRB,TRD
      READ(3,1001) BLR,DLR,FOCB,FOCD
      READ(3,1001) AFHR,PFHR,SUF(2),SUF(3)
      READ(3,1001) BETA,DETA
      READ(2,1003) NOIB,NOID
      READ(2,1001) BMHS,DMHS,SECOB,SECOD
      READ(2,1003) JSEB,JSED,MSEBO,MSEDO
C
      IF (JSEB .EQ. 0) GO TO 2
      DO 2 M = 1, JSEB
        READ(2,1004) AVALB(M),LCOMB(M),USECOB(M),UTILB(M)
2     CONTINUE
C
      IF (JSED .EQ. 0) GO TO 4
      DO 4 M = 1, JSED
        READ(2,1004) AVALD(M),LCOMD(M),USECOD(M),UTILD(M)
4     CONTINUE
      READ(2,1007) MINB,XMINB,MINSEB,MINSED
C
C    *INITIALIZE VARIABLES
C    *ASSUMING A MINIMUM OF ONE REPAIR PERSON PER MAINTENANCE SITE
C    *MINBP AND MINDP ARE BOTH SET TO 1.
C
      MINBP = 1
      MINDP = 1
      BASE = 0.0
      DEPOT = 0.0
      FBLRU = BIT + (1-BIT)*RTSS
C
C    *CALCULATE AMHB AND AMHD
C
      DO 9 I = 1, NLRU
        IF (LMTBF(I) .EQ. 0.) GO TO 5
        BASE = BASE + FBLRU*(BMH(I)*RTS(I) + RTLB(I)*LMTTR(I))/LMTBF(I)
        DEPOT=DEPOT+((1-BIT)*(1-RTSS)+FBLRU*(1-RTS(I))*DMH(I) +
     1        FBLRU*(1-RTLB(I))*LMTTR(I))/LMTBF(I)
5       IF (NSRU(I) .EQ. 0) GO TO 8
        DO 7 J = 1, NSRU(I)
          IF (SMTBF(I,J) .EQ. 0.) GO TO 6
          BASE = BASE + RTS(I)*(RTSB(I,J)*SMTTR(I,J))/SMTBF(I,J)
          DEPOT=DEPOT+(((1-BIT)*(1-RTSS)+FBLRU*((1-RTS(I))+(RTS(I)*(1-
     1          RTSB(I,J)))))*SMTTR(I,J)/SMTBF(I,J))
6         CONTINUE
7       CONTINUE
8       CONTINUE
9     CONTINUE
      AMHB = UMTBF*(((1-BIT)*BMHS)/UMTBF + FBLRU*BASE)
```

```
      AMHD = UMTBF*(((1-BIT)*(1-RTSS)*DMHS/UMTBF) + DEPOT)
C
      DO 200 I = 1, NYRS
        NOB = NBAS(I)
        NOD = NDEP(I)
C
C        *CALCULATE NUMBER OF SYSTEMS OPERATING IN YEAR I
C
        NS = NS + NAV*CRFT(I)
C
C        *CALCULATE PEAK FLIGHT AND TOTAL FLIGHT OPERATING HOURS
C        *FOR AVIONICS SYSTEMS
C
        PFAV = 12*PTHR*NS
        TFAV = 12*AFHR*NS
C
C       **CALCULATE COST OF INITIAL AND REPLACEMENT SPARES
C
        DO 60 J = 1, NLRU
          MTBFL = LMTBF(J)
          IF (MTBFL .EQ. 0.) GO TO 25
          JRTS = RTS(J)
          LRUB = ILRUB(J)
          LRUD = ILRUD(J)
C
C          *INVESTMENT LRUS (NONRECURRING)
C          *DETERMINE IF LRU IS REPAIRABLE OR NON-REPAIRABLE
C
          IF (ITWL(J) .EQ. 1) GO TO 10
C
C          *REPAIRABLE LRUS
C
          YDUM = TFAV*(FBLRU*JRTS*BMT)/(NOB*MTBFL)
          ZDUM = TFAV*(FBLRU*(1-JRTS)*DMT)/(NOD*MTBFL)
C
          BLRU = AINT(NOB*(YDUM + SUF(2)*SQRT(YDUM)))
          MINLRU = MINB*NOB/LCOML(J)
          IF (BLRU .LT. MINLRU) BLRU = MINLRU
C
          DLRU = AINT(NOD*(ZDUM + SUF(2)*SQRT(ZDUM)))
          MINLRU = MINB*NOD/LCOML(J)
          IF (DLRU .LT. MINLRU) DLRU = MINLRU
C
          NLSPRS = BLRU*LRUB + DLRU*LRUD - NSPRL(J)
          GO TO 20
C
C          *NON-REPAIRABLE LRUS
C
10        YDUM = TFAV*FBLRU*BSOBL*LRUB/(NOB*MTBFL)
          ZDUM = TFAV*FBLRU*BSODL*LRUD/(NOD*MTBFL)
          TDUM = TFAV*FBLRU*OSBL*LRUB/MTBFL
          SDUM = TFAV*FBLRU*OSDL*LRUD/MTBFL
```

```
      NLSPRS = AINT(NOB*(YDUM+SUF(2)*SQRT(YDUM)))
     1        + AINT(NOD*(ZDUM+SUF(2)*SQRT(ZDUM)))
     2    + AINT(TDUM) + AINT(SDUM) - NSPRL(J)
20    IF (NLSPRS .LT. 0.) NLSPRS = 0.
      NSPRL(J) = NSPRL(J) + NLSPRS
      NRCOS(I,1) = NRCOS(I,1) + NLSPRS*LUCOS(J)
C
C    *REPLENISHMENT LRUS (RECURRING)
C
      RLSPRS = AINT(TFAV*COND(J)/MTBFL)
      RLCOS(I,1) = RLCOS(I,1) + RLSPRS*LUCOS(J)*(1 + LMKUP)
C
C    *SRU INITIAL AND REPLACEMENT SPARES
C
25    IF (NSRU(J) .EQ. 0) GO TO 50
      DO 50 K = 1, NSRU(J)
        MTBFS = SMTBF(J,K)
        IF (MTBFS .EQ. 0.) GO TO 45
        ISRB = ISRUB(J,K)
        ISRD = ISRUD(J,K)
C
C      *INVESTMENT SRUS (NONRECURRING)
C      *DETERMINE IF SRU(J,K) IS REPAIRABLE OR NON-REPAIRABLE
C
        IF (ITWS(J,K) .EQ. 1) GO TO 30
C
C      *REPAIRABLE SRUS
C
        XDUM = TFAV*(FBLRU*JRTS*RTSB(J,K)*BMT)/(NOB*MTBFS)
        YDUM = TFAV*(FBLRU*(JRTS*(1-RTSB(J,K)) + (1-JRTS))*DMT)
     1    /(NOD*MTBFS)
C
        BSRU=AINT(NOB*(XDUM+SUF(3)*SQRT(XDUM)))
        MINSRU = (XMINB*NOB)/LCOMS(J,K)
        IF (BSRU .LT. MINSRU) BSRU = MINSRU
C
        DSRU = AINT(NOD*(YDUM+SUF(3)*SQRT(YDUM)))
        MINSRU = (XMINB*NOD/LCOMS(J,K))
        IF (DSRU .LT. MINSRU) DSRU = MINSRU
C
        NSSPRS = BSRU*ISRB + DSRU*ISRD - NSPRB(J,K)
        GO TO 40
C
C      *NON-REPAIRABLE SRUS
C
30      XDUM=TFAV*FBLRU*JRTS*BSOB*ISRB/(NOB*MTBFS)
        YDUM = TFAV*FBLRU*(1-JRTS)*BSOD*ISRD/(NOD*MTBFS)
        WDUM=TFAV*FBLRU*JRTS*OSB*ISRB/MTBFS
        TDUM = TFAV*FBLRU*(1-JRTS)*OSD*ISRD/MTBFS
        NSSPRS = AINT(NOB*(XDUM+SUF(3)*SQRT(XDUM)))
     1    + AINT(NOD*(YDUM+SUF(3)*SQRT(YDUM)))
     2    + AINT(WDUM) + AINT(TDUM) - NSPRB(J,K)
```

```
40          IF (NSSPRS .LT. 0.) NSSPRS = 0.
            NSPRB(J,K) = NSPRB(J,K) + NSSPRS
            NRCOS(I,1) = NRCOS(I,1) + NSSPRS*SUCOS(J,K)
C
C          *REPLENISHMENT SRUS (RECURRING)
C
            RSSPRS=AINT(TFAV*CONDB(J,K)/MTBFS)
            RLCOS(I,1) = RLCOS(I,1) + RSSPRS*SUCOS(J,K)*(1 + SMKUP)
45          CONTINUE
50        CONTINUE
60      CONTINUE
C
C     **CALCULATE COSTS OF ON-AIRCRAFT MAINTENANCE
C
C      *NONRECURRING COSTS
C      *NRCOS(I,2) = 0.0
C
C      *RECURRING COSTS
C
        DO 70 J = 1, NLRU
          IF (LMTBF(J).NE.0.) RLCOS(I,2) = RLCOS(I,2) + ((TFAV*RMHB(J)/
     1    LMTBF(J)) + (NS*FPM*PMMH))*BLR
70      CONTINUE
C
C     **CALCULATE COSTS OF OFF-AIRCRAFT MAINTENANCE
C
C      *NONRECURRING COSTS
C      *NRCOS(I,3) = 0.0
C
C      *RECURRING COSTS
C      *RECURRING OFF-AIRCRAFT MAINTENANCE COSTS ARE COMPOSED OF
C      *FOUR SUB-COST CATEGORIES: MATERIALS, LABOR, SHIPPING, &
C      *DOCUMENTATION.
C      *INITIALIZE DUMMY VARIABLES TO ZERO
C
        XLMAT = 0.0
        XSMAT = 0.0
        XLREP = 0.0
        XSREP = 0.0
        XLSHP = 0.0
        XSSHP = 0.0
        XLTTR = 0.0
        XSTTR = 0.0
        LRUT = 0.0
        SRUT = 0.0
        BDOC = (ONAC + OFAC + STR)/UMTBF
        DDOC = (OFAC + STR)/UMTBF
C
C      *CALCULATE COSTS FOR LRU LEVEL OF MAINTENANCE
C      *CALCULATE INTERMEDIATE VALUES WITHIN THE LOOPS AND
C      *THE FINAL VALUES OUTSIDE THE LOOPS
C
```

```
          DO 90 J = 1, NLRU
            JRTS = RTS(J)
            MTBFL = LMTBF(J)
            IF (MTBFL .EQ. 0) GO TO 85
C
C          *MATERIALS--LRU(J)
C
            XLMAT = XLMAT + ((FBLRU*JRTS*RTLB(J)*BMC(J)) + (FBLRU*JRTS
     1             *(1-RTLB(J)) + FBLRU*(1-JRTS))*DMC(J))/MTBFL
C
C          *LABOR--LRU(J)
C
           XLREP = XLREP + FBLRU*JRTS*LMTTR(J)*(1-ITWL(J))*(RTLB(J)*BLR +
     +             (1-RTLB(J))*DLR)/MTBFL
C
C          *SHIPPING--LRU(J)
C
            XLSHP = XLSHP + (WT(J)*(FBLRU*((1-JRTS)+JRTS*(1-RTLB(J))))*2
     1             *YMIL*SSHC*(1-ITWL(J)) + (FBLRU*(1-JRTS)*(YMIL*SS4C+
     2             XMIL*SHC)*ITWL(J)))/MTBFL)
C
C          *WEIGHT OF EQUIPMENT SHIPPED TO REPLACE CONDEMNED LRU(J)
C
            XLTTR = XLTTR + WT(J)*COND(J)*(1-ITWL(J))/MTBFL
C
C          *DOCUMENTATION FOR MAINTENANCE--LRU(J)
C
            LRUT = LRUT + (FBLRU*(1-JRTS))/MTBFL
C
C          *CALCULATE COSTS FOR SRU LEVEL OF MAINTENANCE
C
            IF (NSRU(J) .EQ. 0) GO TO 85
            DO 80 K = 1, NSRU(J)
              XRTSB = RTSB(J,K)
              MTBFS = SMTBF(J,K)
              IF (MTBFS .EQ. 0.) GO TO 75
C
C             *MATERIALS--SRU(J,K)
C
              XSMAT = XSMAT + ((FBLRU*JRTS*XRTSB*BMCS(J,K))+(FBLRU*(JRTS
     1             *(1-XRTSB)+(1-JRTS))*DMCS(J,K)))/MTBFS
C
C             *LABOR--SRU(J,K)
C
              XSREP = XSREP + ((FBLRU*JRTS*XRTSB*SMTTR(J,K)*BLR) +
     1             (FBLRU*(JRTS*(1-XRTSB)+(1-JRTS))*SMTTR(J,K)*DLR))
     2             *(1-ITWS(J,K))/MTBFS
C
C             *SHIPPING--SRU(J,K)
C
              XSSHP = XSSHP + (WTB(J,K)*((FBLRU*JRTS*(1-XRTSB)*2*YMIL*SSHC
     1             *(1-ITWS(J,K))) + (FBLRU*JRTS*(YMIL*SSHC+XMIL*SHC)
```

```
     2               *ITWS(J,K)))/MTBFS)
C
C          *WEIGHT OF EQUIPMENT SHIPPED TO REPLACE CONDEMNED SRU(J,K)
C
            XSTTR = XSTTR + WTB(J,K)*CONDB(J,K)*(1-ITWS(J,K))/MTBFS
C
C          *DOCUMENTATION FOR MAINTENANCE--SRU(J,K)
C
            SRUT = SRUT + (FBLRU*JRTS*(1-XRTSB))/MTBFS
75          CONTINUE
80        CONTINUE
85      CONTINUE
90      CONTINUE
C
C       *MAKE FINAL CALCULATIONS IN EACH SUB-CATEGORY
C       *COST OF MATERIALS
C
        TMAT = TFAV*(XLMAT + XSMAT)
C
C       *COST OF LABOR
C
        TLABOR = TFAV*(XLREP + XSREP)
C
C       *COST OF SHIPPING
C
        TSHIP = PACK*TFAV*((XLTTR + XSTTR)*(YMIL*SSHC + XMIL*SHC)
     1    + (XLSHP + XSSHP))
C
C       *COST OF MAINTENANCE DOCUMENTATION
C
C       *BASE LEVEL
C
        BDMTD = (BDOC + (LRUT+SRUT)*TFR)*TFAV*BLR
C
C       *DEPOT LEVEL
C
        DDMTD = (DDOC + (LRUT+SRUT)*TFR)*TFAV*DLR
C
C       *TOTAL OFF-AIRCRAFT MAINTENANCE RECURRING EXPENSE
C
        RLCOS(I,3) = RLCOS(I,3) + TMAT + TLABOR + TSHIP + BDMTD + DDMTD
C
C      **CALCULATE COSTS OF INVENTORY ENTRY AND SUPPLY MANAGEMENT
C
        NICB = 1
        IF (FRAV .EQ. 0.0) NICB = 0
C
C       *NONRECURRING COSTS
C
100     IF (I .NE. 1) GO TO 110
C
```

```
C       *IF (I .NE. 1) NRCOS(I,4) = 0.0
C
         NRCOS(I,4) = NRCOS(I,4) + IAMC*NIC*TIC*NICB
C
C       *RECURRING COSTS
C
         RLCOS(I,4) = RLCOS(I,4) + (NOB*NOIB*HOLDB + NOD*NOID*HOLDD
     1    )*NICB
         GO TO 115
110      RLCOS(I,4) = RLCOS(I,4) + (IAMC*NIC*TIC + NOB*NOIB*HOLDB +
     1                NOD*NOID*HOLDD)*NICB
C
C      **CALCULATE COSTS OF SPECIAL SUPPORT EQUIPMENT
C
115      TBMH = 0.0
         TDMH = 0.0
         DO 112 L = 1,NLRU
           TBMH = TBMH + BMH(L)
           TDMH = TDMH + DMH(L)
112      CONTINUE
C
C       *BASE SUPPORT EQUIPMENT
C
         IF (JSEB .EQ. 0) GO TO 120
         DO 120 L = 1, JSEB
C
C         *NONRECURRING COSTS
C
           XNSEB = AINT(PFAV*TBMH*UTILB(L)/(UMTBF*AVALB(L)*BETA))
           YNSEB = MINSEB*NOB/LCOMB(L)
           IF (XNSEB .LT. YNSEB) XNSEB = YNSEB
           NNSEB(I) = NNSEB(I) + ((XNSEB-NSEB(L))*USECOB(L))
           NSEB(L) = XNSEB
C
C         *RECURRING COSTS
C
           XRSEB = PFAV*TBMH*UTILB(L)*SECOB/(UMTBF*AVALB(L)*BETA)
           YRSEB = MSEBO*NSEB(L)
           IF (XRSEB .LT. YRSEB) XRSEB = YRSEB
           RNSEB(I) = RNSEB(I) + XRSEB
120      CONTINUE
C
C       *DEPOT SUPPORT EQUIPMENT
C
         IF (JSED .EQ. 0) GO TO 130
         DO 130 L = 1, JSED
C
C         *NONRECURRING COSTS
C
           XNSED = AINT(PFAV*TDMH*UTILD(L)/(UMTBF*AVALD(L)*BETA))
           YNSED = MINSED*NOD/LCOMD(L)
```

```
         IF (XNSED .LT. YNSED) XNSED = YNSED
         NNSED(I) = NNSED(I) + ((XNSED-NSED(L))*USECOD(L))
         NSED(L) = XNSED
C
C       *RECURRING COSTS
C
         XRSED = PFAV*TDMH*UTILD(L)*SECOD/(UMTBF*AVALD(L)*DETA)
         YRSED = MSEDO*NSED(L)
         IF (XRSED .LT. YRSED) XRSED = YRSED
         RNSED(I) = RNSED(I) + XRSED
130     CONTINUE
C
C      *TOTAL NONRECURRING COST, SPECIAL SUPPORT EQUIPMENT
C
        NRCOS(I,5) = NRCOS(I,5) + NNSEB(I) + NNSED(I)
C
C      *TOTAL RECURRING COST, SPECIAL SUPPORT EQUIPMENT
C
        RLCOS(I,5) = RLCOS(I,5) + RNSEB(I) + RNSED(I)
C
C
C     **CALCULATE COST OF TRAINING PERSONNEL
C
C      *NONRECURRING COSTS (INITIAL TRAINING)
C      *BASE LEVEL
C
        XBPER = AINT((TFAV*AMHB/(PMB*PRODB*UMTBF)))
        YBPER = MINBP*NOB
        IF (XBPER .LT. YBPER) XBPER = YBPER
        NBPER(I) = NBPER(I) + (XBPER - NPERB)
C
C      *DEPOT LEVEL
C
        XDPER = AINT((TFAV*AMHD/(PMD*PRODD*UMTBF)))
        YDPER = MINDP*NOD
        IF (XDPER .LT. YDPER) XDPER = YDPER
        NDPER(I) = NDPER(I) + (XDPER - NPERD)
C
C      *TOTAL NONRECURRING
C
        NRCOS(I,6) = NRCOS(I,6) + NBPER(I)*TCOSB + NDPER(I)*TCOSD
C
C      *RECURRING COST (DUE TO PERSONNEL TURNOVER)
C
        RLCOS(I,6) = RLCOS(I,6) + NPERB*TCOSB*TRB + NPERD*TCOSD*TRD
        NPERB = XBPER
        NPERD = XDPER
C
C
C     **CALCULATE COSTS OF DATA MANAGEMENT AND TECHNICAL DOCUMENTATION
C
```

```
C       *NONRECURRING COSTS
C
         IF (I .NE. 1) GO TO 135
         NNBAS = NOB
         NNDEP = NOD
         GO TO 137
135      NNBAS = NOB - NBAS(I-1)
         NNDEP = NOD - NDEP(I-1)
137      NRCOS(I,7) = NRCOS(I,7) + CPP*(NPBD*NNBAS + NPDD*NNDEP)
C
C       *RECURRING COSTS
C       *RLCOS(I,7) = 0.0
C
C
C     **CALCULATE COST OF FACILITIES
C
C        *NONRECURRING COSTS
C        *NRCOS(I,8) = 0.0
C
C       *RECURRING COSTS
C
         RLCOS(I,8) = RLCOS(I,8) + FOCB*NOB + FOCD*NOD
C
C    *TOTAL NONRECURRING AND RECURI     GISTICS COSTS FOR YEAR I
C
         DO 160 J = 1, 8
           TNRCOS(I) = TNRCOS(I) + NRCOS(I,J)
           TRLCOS(I) = TRLCOS(I) + RLCOS(I,J)
160      CONTINUE
CC      *TOTAL LOGISTIC COSTS FOR YEAR I
C
         TLLCOS(I) = TNRCOS(I) + TRLCOS(I)
200    CONTINUE
C
C    *FORMAT STATEMENTS
C
1001   FORMAT(10X,F8.2,3(7X,F8.2))
1002   FORMAT(10X,F8.3,7X,F8.3,2(7X,I8))
1003   FORMAT(10X,I8,7X,I8,2(7X,F8.2))
1004   FORMAT(10X,F8.2,7X,I8,2(7X,F8.2))
1005   FORMAT(10X,F8.2,2(7X,I8))
1006   FORMAT(10X,4(F8.3,7X))
1007   FORMAT(3X,4(7X,I8))
C
       RETURN
       END
```

```
C                          SUBROUTINE TOTCUM
C
C         THE TOTCUM MODULE CALCULATES THE TOTAL LOGISTIC SUPPORT
C         COSTS INCURRED EACH YEAR AND THE CUMULATIVE ACQUISITION,
C         INSTALLATION, AND LOGISTIC SUPPORT COSTS INCURRED PRIOR TO
C         YEAR I.
C
      SUBROUTINE TOTCUM(NYRS)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
      COMMON/CAT/CLCC, TNRCAT(9), TRLCAT(9), TPROG(25), CPROG(25)
      COMMON/INSTAL/ICOS(25), TCOSI(25)
      COMMON/LOGIST/NRCOS(25,3), RLCOS(25,8), TCOSL(25), TLLCOS(25),
     1              TNRCOS(25), TRLCOS(25), TCOSN(25), TCOSR(25)
C
C     *DECLARE VARIABLES
C
      INTEGER YEAR
      REAL ICOS, NAC, NRCOS, NRAC
C
C     *INITIALIZE VARIABLES
C
      DO 1 I = 1, NYRS
        TCOSA(I) = 0.0
        TCOSI(I) = 0.0
        TCOSN(I) = 0.0
        TCOSR(I) = 0.0
        TCOSL(I) = 0.0
        CPROG(I) = 0.0
1     CONTINUE
      DO 2 J = 1, 9
        TNRCAT(J) = 0.0
        TRLCAT(J) = 0.0
2     CONTINUE
      CLCC = 0.0
C
      DO 30 I = 1, NYRS
        DO 10 J = I, NYRS
C
C         *DETERMINE CUMULATIVE ACQUISITION COSTS
C
          TCOSA(J) = TCOSA(J) + ACOS(I)
C
C         *DETERMINE CUMULATIVE INSTALLATION COSTS
C
          TCOSI(J) = TCOSI(J) + ICOS(I)
C
C         *DETERMINE CUMULATIVE LOGISTIC SUPPORT COSTS
C
          TCOSN(J) = TCOSN(J) + TNRCOS(I)
```

```
          TCOSR(J) = TCOSR(J) + TRLCOS(I)
          TCOSL(J) = TCOSL(J) + TLLCOS(I)
C
C        *DETERMINE CUMULATIVE PROGRAM COSTS
C
          CPROG(J) = CPROG(J) + ACOS(I) + ICOS(I) + TLLCOS(I)
10      CONTINUE
C
C       *DETERMINE TOTAL PROGRAM COST FOR YEAR I
C
        TPROG(I) = TLLCOS(I) + ACOS(I) + ICOS(I)
C
C       *DETERMINE CUMULATIVE PROGRAM COST
C
        CLCC = CLCC + TPROG(I)
C
C       *DETERMINE TOTAL FOR EACH LOGISTIC CATEGORY
C
        DO 20 J = 1, 8
          TNRCAT(J) = TNRCAT(J) + NRCOS(I,J)
          TNRCAT(9) = TNRCAT(9) + NRCOS(I,J)
          TRLCAT(J) = TRLCAT(J) + RLCOS(I,J)
          TRLCAT(9) = TRLCAT(9) + RLCOS(I,J)
20      CONTINUE
30    CONTINUE
C
      RETURN
      END
```

```
C                               SUBROUTINE PERGAC
C
C       THE PERGAC MODULE CALCULATES THE COST PER GA OWNER AND THE COST
C       PER GENERAL AVIATION AIRCRAFT FOR EACH YEAR IN THE LIFE CYCLE OF
C        THE SPECIFIED AVIONICS EQUIPMENT.
C
      SUBROUTINE PERGAC(NYRS,DSCNT)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
      COMMON/INSTAL/ICOS(25), TCOSI(25)
      COMMON/LOGIST/NRCOS(25,8), RLCOS(25,8), TCOSL(25), TLLCOS(25),
     1              TNRCOS(25), TRLCOS(25), TCOSN(25), TCOSR(25)
      COMMON/NAMES/SNAME, UNAME
C
C     *DECLARE VARIABLES
C
      INTEGER LB, NYRS, UB, YEAR
      REAL ACOS,CLCC,CRFT,ICOS,NAC,NNAC,NRAC,NRCOS
      REAL PEROWN(25),RLCOS,TCOSA,TCOSI,TCOSL,TLCOS,TLLCOS
      REAL TNRCOS,TRLCOS,NCRFT,PERAC(25)
      LOGICAL*1 SNAME(65),UNAME(35)
C
C     *INITIALIZE VARIABLES
C
      TLCOS = 0.0
      NCRFT = 0.0
C
      DO 10 I = 1, NYRS
C
C      *CALCULATE COST PER OWNER OF AVIONICS EQUIPMENT
C      *NOTE: THE TOTAL LOGISTIC COSTS INCURRED BY THE GA OWNER ARE
C        RESTRICTED TO RECURRING MAINTENANCE.
C
        NCRFT = NCRFT + CRFT(I)
        PERAC(I) = (TCOSN(I) + TRLCOS(I))/NCRFT
        PEROWN(I)  = TRLCOS(I)/NCRFT
10    CONTINUE
C
C     *PRINT RESULTS
C
      WRITE(6,1005) (SNAME(I), I = 1, 65)
      WRITE(6,1006) (UNAME(I), I = 1, 35)
      WRITE(6,1007) DSCNT
      WRITE(6,1001)
      LB = 1
      UB = 3
      NO = NYRS/UB
      N1 = 1
      N2 = NO
```

```
      DO 20 I = LB, UB
        WRITE(6,1002) (YEAR(J), J = N1, N2)
        WRITE(6,1004) (PERAC(J), J = N1, N2)
        WRITE(6,1003) (PEROWN(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .GT. NYRS) N2 = NYRS
20    CONTINUE
C
C    *FORMAT STATEMENTS
C
1001  FORMAT(1X,//,59X,'AVIONICS COST PER YEAR',/)
1002  FORMAT(1X,//,28X,7(6X,I4,5X))
1003  FORMAT(9X,'COST PER OWNER ', 7(2X,F13.2))
1004  FORMAT(9X,'COST PER A/C    ', 7(2X,F13.2))
1005  FORMAT(1H1,///,4X,'SYSTEM: ',65A1)
1006  FORMAT(4X,'USER:     ',35A1)
1007  FORMAT(4X,'DISCOUNT FACTOR:',F4.2)
      RETURN
      END
```

```
C                              SUBROUTINE OUTTAB
C
C         THE OUTTAB MODULE OUTPUTS ALL OF THE VALUES COMPUTED IN
C         THE LIFE CYCLE COSTING MODEL IN TABULAR FORM.
C
        SUBROUTINE OUTTAB(NYRS,DSCNT)
C
C      *ESTABLISH COMMON BLOCKS
C
        COMMON/ACQUIZ/ACOS(25), TCOSA(25)
        COMMON/ARCRFT/CRFT(25), NAC(25), NRAC(25), YEAR(25)
        COMMON/CAT/CLCC, TNRCAT(9), TRLCAT(9), TPROG(25), CPROG(25)
        COMMON/INSTAL/ICOS(25), TCOSI(25)
        COMMON/LOGIST/NRCOS(25,8), RLCOS(25,8), TCOSL(25), TLLCOS(25),
       1                TNRCOS(25), TRLCOS(25), TCOSN(25), TCOSR(25)
        COMMON/MISCLO/NBAS(25),NDEP(25),UMTBF,UCOS
        COMMON/NAMES/SNAME,UNAME
C
C      *DECLARE VARIABLES
C
        INTEGER YEAR,UB
        REAL ICOS, NRAC, NAC, NRCOS
        LOGICAL*1 ANS, SNAME(65), UNAME(35)
C
C      *INITIALIZE VARIABLES
C
        NO = NYRS/3
        LB = 1
        UB = 2
C
        WRITE(1,*) 'DO YOU WANT A NONRECURRING/RECURRING COST BREAKDOWN?'
        READ(1,1050) ANS
        IF (ANS .NE. 'Y') GO TO 27
C      *PRINT HEADINGS, INVESTMENT COSTS
C
        WRITE(6,1034) (SNAME(I), I = 1,65)
        WRITE(6,1035) (UNAME(I), I = 1,35)
        WRITE(6,1036) DSCNT
        WRITE(6,1000)
        N1 = 1
        N2 = NO
C
C      *PRINT NONRECURRING COSTS FOR EACH YEAR BY CATEGORY
C
        DO 10 I = LB, UB
          WRITE(6,1001) (YEAR(J), J = N1, N2)
          WRITE(6,1002) (NRCOS(J,1), J = N1, N2)
          WRITE(6,1005) (NRCOS(J,4), J = N1, N2)
          WRITE(6,1006) (NRCOS(J,5), J = N1, N2)
          WRITE(6,1007) (NRCOS(J,6), J = N1, N2)
          WRITE(6,1008) (NRCOS(J,7), J = N1, N2)
          WRITE(6,1009) (NRCOS(J,8), J = N1, N2)
```

```
        WRITE(6,1010) (TNRCOS(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 10
        N2 = NYRS
        GO TO 15
10    CONTINUE
15    WRITE(6,1026) (YEAR(J),J = N1, N2)
      WRITE(6,1027)
      WRITE(6,1012) (NRCOS(J,1), J = N1, N2)
      WRITE(6,1013) TNRCAT(1)
      WRITE(6,1016) (NRCOS(J,4), J = N1, N2)
      WRITE(6,1013) TNRCAT(4)
      WRITE(6,1017) (NRCOS(J,5), J = N1, N2)
      WRITE(6,1013) TNRCAT(5)
      WRITE(6,1018) (NRCOS(J,6), J = N1, N2)
      WRITE(6,1013) TNRCAT(6)
      WRITE(6,1019) (NRCOS(J,7), J = N1, N2)
      WRITE(6,1013) TNRCAT(7)
      WRITE(6,1020) (NRCOS(J,8), J = N1, N2)
      WRITE(6,1013) TNRCAT(8)
      WRITE(6,1021) (TNRCOS(J), J = N1, N2)
      WRITE(6,1013) TNRCAT(9)
C
C    *PRINT HEADINGS- OPERATING AND SUPPORT COSTS
C
      WRITE(6,1034) (SNAME(I), I = 1, 65)
      WRITE(6,1035) (UNAME(I), I = 1, 35)
      WRITE(6,1036) DSCNT
      WRITE(6,1028)
      N1 = 1
      N2 = NO
C
C    *PRINT RECURRING COSTS FOR EACH CATEGORY BY YEAR
C
      DO 20 I = LB, UB
        WRITE(6,1001) (YEAR(J), J = N1, N2)
        WRITE(6,1002) (RLCOS(J,1), J = N1, N2)
        WRITE(6,1003) (RLCOS(J,2), J = N1, N2)
        WRITE(6,1004) (RLCOS(J,3), J = N1, N2)
        WRITE(6,1005) (RLCOS(J,4), J = N1, N2)
        WRITE(6,1006) (RLCOS(J,5), J = N1, N2)
        WRITE(6,1007) (RLCOS(J,6), J = N1, N2)
        WRITE(6,1008) (RLCOS(J,7), J = N1, N2)
        WRITE(6,1009) (RLCOS(J,8), J = N1, N2)
        WRITE(6,1010) (TRLCOS(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 20
        N2 = NYRS
        GO TO 25
20    CONTINUE
```

```
25    WRITE(6,1026) (YEAR(J), J = N1, N2)
      WRITE(6,1027)
      WRITE(6,1012) (RLCOS(J,1), J = N1, N2)
      WRITE(6,1013) TRLCAT(1)
      WRITE(6,1014) (RLCOS(J,2), J = N1, N2)
      WRITE(6,1013) TRLCAT(2)
      WRITE(6,1015) (RLCOS(J,3), J = N1, N2)
      WRITE(6,1013) TRLCAT(3)
      WRITE(6,1016) (RLCOS(J,4), J = N1, N2)
      WRITE(6,1013) TRLCAT(4)
      WRITE(6,1017) (RLCOS(J,5), J = N1, N2)
      WRITE(6,1013) TRLCAT(5)
      WRITE(6,1018) (RLCOS(J,6), J = N1, N2)
      WRITE(6,1013) TRLCAT(6)
      WRITE(6,1019) (RLCOS(J,7), J = N1, N2)
      WRITE(6,1013) TRLCAT(7)
      WRITE(6,1020) (RLCOS(J,8), J = N1, N2)
      WRITE(6,1013) TRLCAT(8)
      WRITE(6,1021) (TRLCOS(J), J = N1, N2)
      WRITE(6,1013) TRLCAT(9)
C
C     *PRINT HEADINGS FOR TOTAL LIFE CYCLE COSTS BY YEAR
C
27    WRITE(6,1034) (SNAME(I), I = 1, 65)
      WRITE(6,1035) (UNAME(I), I = 1, 35)
      WRITE(6,1036) DSCNT
      WRITE(6,1042) UCOS,UMTBF
      WRITE(6,1029)
      N1 = 1
      N2 = NO
C
C     *PRINT RESULTS
C
      DO 30 I = LB, UB
        WRITE(6,1001) (YEAR(J), J = N1, N2)
        WRITE(6,1030) (ACOS(J), J = N1, N2)
        WRITE(6,1031) (ICOS(J), J = N1, N2)
        WRITE(6,1037) (TNRCOS(J), J = N1, N2)
        WRITE(6,1038) (TRLCOS(J), J = N1, N2)
        WRITE(6,1032) (TLLCOS(J), J = N1, N2)
        WRITE(6,1033) (TPROG(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 30
        N2 = NYRS
        GO TO 35
30    CONTINUE
35    WRITE(6,1026) (YEAR(J), J = N1, N2)
      WRITE(6,1027)
      WRITE(6,1022) (ACOS(J), J = N1, N2)
      WRITE(6,1013) TCOSA(NYRS)
      WRITE(6,1023) (ICOS(J), J = N1, N2)
```

```
      WRITE(6,1013) TCOSI(NYRS)
      WRITE(6,1040) (TNRCOS(J), J = N1, N2)
      WRITE(6,1013) TCOSN(NYRS)
      WRITE(6,1041) (TPLCOS(J), J = N1, N2)
      WRITE(6,1013) TCOSR(NYRS)
      WRITE(6,1024) (TLLCOS(J), J = N1, N2)
      WRITE(6,1013) TCOSL(NYRS)
      WRITE(6,1025) (TPROG(J), J = N1, N2)
      WRITE(6,1013) CLCC
C
C     *PRINT HEADINGS FOR CUMULATIVE LIFE CYCLE COSTS BY YEAR
C
      WRITE(6,1039)
      N1 = 1
      N2 = NO
C
C     *PRINT RESULTS
C
      DO 40 I = LB, UB+1
        WRITE(6,1001) (YEAR(J), J = N1, N2)
        WRITE(6,1030) (TCOSA(J), J = N1, N2)
        WRITE(6,1031) (TCOSI(J), J = N1, N2)
        WRITE(6,1037) (TCOSN(J), J = N1, N2)
        WRITE(6,1038) (TCOSR(J), J = N1, N2)
        WRITE(6,1032) (TCOSL(J), J = N1, N2)
        WRITE(6,1033) (CPROG(J), J = N1, N2)
        N1 = N1 + NO
        N2 = N2 + NO
        IF (N2 .LT. NYRS) GO TO 40
        N2 = NYRS
40    CONTINUE
C
C     *FORMAT STATEMENTS
C
1000  FORMAT(49X,'NONRECURRING LOGISTIC SUPPORT COSTS',//)
1001  FORMAT(1X,//,9X,'COST CATEGORY   ', 2X, 7(6X,I4,5X),/)
1002  FORMAT(9X,'SPARES            ', 8(2X,F13.0))
1003  FORMAT(9X,'ON-A/C MAINT      ', 8(2X,F13.0))
1004  FORMAT(9X,'OFF-A/C MAINT     ', 8(2X,F13.0))
1005  FORMAT(9X,'INVENTORY MGT     ', 8(2X,F13.0))
1006  FORMAT(9X,'SUPPORT EQUIP     ', 8(2X,F13.0))
1007  FORMAT(9X,'TRAINING          ', 8(2X,F13.0))
1008  FORMAT(9X,'DATA MANAGEMENT', 8(2X,F13.0))
1009  FORMAT(9X,'FACILITIES        ', 8(2X,F13.0))
1010  FORMAT(9X,'ANNUAL TOTAL      ', 8(2X,F13.0))
1012  FORMAT('$',8X,'SPARES              ',8(2X,F13.0))
1013  FORMAT('+',2X,F13.0)
1014  FORMAT('$',8X,'ON-A/C MAINT     ',8(2X,F13.0))
1015  FORMAT('$',8X,'OFF-A/C MAINT    ',8(2X,F13.0))
1016  FORMAT('$',8X,'INVENTORY MGT    ',8(2X,F13.0))
1017  FORMAT('$',8X,'SUPPORT EQUIP    ',8(2X,F13.0))
1018  FORMAT('$',8X,'TRAINING         ',8(2X,F13.0))
```

```
1019  FORMAT('$',8X,'DATA MANAGEMENT',8(2X,F13.0))
1020  FORMAT('$',8X,'FACILITIES      ',8(2X,F13.0))
1021  FORMAT('$',8X,'ANNUAL TOTAL    ',8(2X,F13.0))
1022  FORMAT('$',8X,'ACQUISITION     ',8(2X,F13.0))
1023  FORMAT('$',8X,'INSTALLATION    ',8(2X,F13.0))
1024  FORMAT('$',8X,'TOTAL LOGISTIC  ',8(2X,F13.0))
1025  FORMAT('$',8X,'TOTAL PROGRAM   ',8(2X,F13.0))
1026  FORMAT(1X,//,'$',8X,'COST CATEGORY   ',2X,7(6X,I4,5X))
1027  FORMAT('+',2X,'TOTAL')
1028  FORMAT(52X,'RECURRING LOGISTIC SUPPORT COSTS',//)
1029  FORMAT(56X,'TOTAL LIFE CYCLE COSTS BY YEAR')
1030  FORMAT(9X,'ACQUISITION     ',8(2X,F13.0))
1031  FORMAT(9X,'INSTALLATION    ',8(2X,F13.0))
1032  FORMAT(9X,'TOTAL LOGISTIC  ',8(2X,F13.0))
1033  FORMAT(9X,'TOTAL PROGRAM   ',8(2X,F13.0))
1034  FORMAT(1H1,3X,'SYSTEM: ',65A1)
1035  FORMAT(4X,'USER:     ',35A1)
1036  FORMAT(4X,'DISCOUNT FACTOR:',F4.2)
1037  FORMAT(9X,'NONRECURRING    ',8(2X,F13.0))
1038  FORMAT(9X,'RECURRING       ',8(2X,F13.0))
1039  FORMAT(1X,//,50X,'CUMULATIVE LIFE CYCLE COSTS BY YEAR')
1040  FORMAT('$',8X,'NONRECURRING    ',8(2X,F13.0))
1041  FORMAT('$',8X,'RECURRING       ',8(2X,F13.0))
1042  FORMAT(4X,'SYSTEM COST:',F10.2,'  SYSTEM MTBF:',F8.1)
1050  FORMAT(10A1)
      RETURN
      END
```

```
C                            SUBROUTINE DISCNT
C
C       THE DISCNT MODULE DISCOUNTS THE ACQUISITION, INSTALLATION,
C       NONRECURRING AND RECCURRING LOGISTIC COSTS FOR ALL YEARS
C       AND CATEGORIES.
C       *NOTE: THE CONSTANT DOLLAR COST ARRAY VALUES ARE CHANGED
C       DUE TO THE USE OF THE COMMON STATEMENT.
C
      SUBROUTINE DISCNT(NYRS,XDIS,BASEYR)
C
C     *ESTABLISH COMMON BLOCKS
C
      COMMON/ACQUIZ/ACOS(25), TCOSA(25)
      COMMON/ARCRFT/CRFT(25),NAC(25),NRAC(25),YEAR(25)
      COMMON/INSTAL/ICOS(25), TCOSI(25)
      COMMON/LOGIST/NRCOS(25,8), RLCOS(25,8), TCOSL(25), TLLCOS(25),
     1              TNRCOS(25), TRLCOS(25), TCOSN(25), TCOSR(25)
      COMMON/CAT/CLCC, TNRCAT(9), TRLCAT(9), TPROG(25), CPROG(25)
C
C     *DECLARE VARIABLES
C
      INTEGER BASEYR,YEAR
      REAL ICOS, NRCOS, NAC, NRAC
C
      DO 20 I = 1, NYRS
C
C      *COMPUTE THE DISCOUNT FACTOR FOR YEAR I
C
        N = YEAR(I) - BASEYR
        DISC = (1/(1+XDIS))**N
C
C      *DISCOUNT ALL COST ARRAYS
C
        ACOS(I) = ACOS(I)*DISC
        ICOS(I) = ICOS(I)*DISC
        TPROG(I) = TPROG(I)*DISC
        TNRCOS(I) = TNRCOS(I)*DISC
        TRLCOS(I) = TRLCOS(I)*DISC
        TLLCOS(I) = TLLCOS(I)*DISC
        DO 10 J = 1, 8
          NRCOS(I,J) = NRCOS(I,J)*DISC
          RLCOS(I,J) = RLCOS(I,J)*DISC
10      CONTINUE
20    CONTINUE
C
      RETURN
      END
```

APPENDIX I

PARAMETER SUMMARY
FOR LIFE-CYCLE-COST MODEL
FOR AIRBORNE EQUIPMENT

PARAMETER NAME	DESCRIPTION	*COMMERCIAL CARRIER	**HIGH PERFORMANCE GENERAL AVIATION	**LOW PERFORMANCE GENERAL AVIATION
AFHR	Average flight hours per month per A/C	220 hrs.	35 hrs.	15.8 hrs.
AMCOS	Amortization cost	0	0	0
$AVALB_L$	Availability of Lth type base support equipment	N/A	1	1
$AVALD_L$	Availability of Lth type depot support equipment	1	1	1
BETA	Base support equipment time available per month (hrs)	N/A	160 hrs.	160 hrs.
BIT	Fraction of failures isolated to LRU by Built-In Test Equipment	0.70	0.00	0.00
BLR	Base labor rate ($/hr)	$30.29/hr.	$28.40/hr.	$25.25/hr.
BMC_J	Average base materials cost per maintenance action on Jth LRU	Variable	Variable	Variable
$BMCS_{J,K}$	Average base materials cost per maintenance action on Kth SRU in Jth LRU	Variable	Variable	Variable
BMH_J	Average labor-hours to isolate LRU_J failure to SRU level base	Variable	Variable	Variable
BMHS	Average labor-hours to isolate failure to LRU, base	0.50	0.50	0.50
BMT	Average base turnaround time (mo.)	0.100	0.100	0.033
BSOB	Base SRU stocking objective (mo.)	N/A	N/A	N/A
BSOBL	Base LRU stocking objective (mo.)	N/A	N/A	N/A
BSOD	Depot SRU stocking objective (mo.)	N/A	N/A	N/A
BSODL	Depot LRU stocking objective (mo.)	N/A	N/A	N/A
$COND_J$	Fraction LRU_J failures resulting in condemnations	Variable	Variable	Variable
$CONDB_{J,K}$	Fraction $SRU_{J,K}$ failures resulting in condemnations	Variable	Variable	Variable

* For commercial carriers, a "Base" represents an airport repair facility and a "Depot" represents an air carrier maintenance facility and MLS manufacturers.

**For general aviation, a "Base" represents any FAA certified avionics repair facility and a "Depot" represents any MLS manufacturer.

PARAMETER NAME	DESCRIPTION	COMMERCIAL CARRIER	HIGH PERFORMANCE GENERAL AVIATION	LOW PERFORMANCE GENERAL AVIATION
CPP	Cost per page, original technical documentation	N/A	N/A	N/A
DETA	Depot support equipment time available per month (hrs)	160 hrs.	160 hrs.	160 hrs.
DIST	Percentage mark-up by distributors on full unit	0.00	0.30	0.60
DLR	Depot labor rate	$30.29/hr.	$27.76/hr.	$27.76/hr.
DMC_J	Average depot materials cost per maintenance action on Jth LRU	Variable	Variable	Variable
$DMCS_{J,K}$	Average depot materials cost per maintenance action on Kth SRU in Jth LRU	Variable	Variable	Variable
DMH_J	Average labor-hours to isolate LRU_J failure to SRU level, depot	Variable	Variable	Variable
DMHS	Average labor-hours to isolate failure to LPU level, depot	N/A	N/A	N/A
DMT	Depot turnaround time (mo.)	0.268 mo.	0.268 mo.	0.268 mo.
FOCB	Annual base facilities cost attributable to system being analyzed	N/A	N/A	N/A
FOCD	Annual depot facilities cost attributable to system being analyzed	$315	N/A	N/A
FPM	Annual frequency of preventive maintenance	N/A	N/A	N/A
FRAV	Fraction of A/C in user category having specified avionics	1.00	1.00	1.00
FUCOS	Average sell price less amortization of avionics unit	$34,035	$11,708	$1,297
HOLDB	Average annual holding cost per item type, base	$0.00	N/A	N/A
HOLDD	Average annual holding cost per item type, depot	$9.75	N/A	N/A
IANC	Cost of introducing each new inventory coded item	$26.00	N/A	N/A
$ILRUB_J$	Base sparing flag for LRU_J	1	0	0
$ILRUD_J$	Depot sparing flag for LRU_J	1	0	0
INCOS	Installation cost of avionics in new A/C	$6,940	$5,860	$195
$ISRUB_{J,K}$	Base sparing flag for $SRU_{J,K}$	Variable	Variable	Variable
$ISRUD_{J,K}$	Depot sparing flag for $SRU_{J,K}$	Variable	Variable	Variable
$ITWL_J$	Repair/throw-away flag for Jth LRU	Variable	Variable	Variable

PARAMETER NAME	DESCRIPTION	COMMERCIAL CARRIER	HIGH PERFORMANCE GENERAL AVIATION	LOW PERFORMANCE GENERAL AVIATION
JSEB	Number of different types of base support equipment	N/A	1	1
JSED	Number of different types of depot support equipment	1	1	1
$LCOMB_L$	Number avionics unit types to which Lth type base support equipment is common	N/A	1	1
$LCOMD_L$	Number avionics unit types to which Lth type depot support equipment is common	1	1	1
$LCOML_J$	Number avionics unit types to which Jth LRU is common	Variable	Variable	Variable
$LCOMS_{J,K}$	Numbe. avionics unit type to which $SRU_{J,K}$ is common	Variable	Variable	Variable
LDIST	Percentage mark-up by distributors on LRUs	0.00	0.00	0.00
$LMTBF_J$	Mean time between failures (MTBF) of Jth LRU	Variable	Variable	Variable
$LMTTR_J$	Mean time to repair LRU_J	Variable	Variable	Variable
$LUCOS_J$	Unit cost of Jth LRU	Variable	Variable	Variable
MINSEB	Minimum number support equipment sets per type per base	N/A	1	1
MINSED	Minimum number support equipment sets per type per depot	1	1	1
MSEBO	Minimum annual support equipment operating cost, base	N/A	N/A	N/A
MSEDO	Minimum annual support equipment operating cost, depot	N/A	N/A	N/A
NAV	Average number avionics units per A/C	1	1	1
NBAS	Number of bases	135	Variable	Variable
NDEP	Number of depots	23	Variable	Variable
NIC	Fraction of inventory coded items that are new	1.0	N/A	N/A
NLRU	Number LRUs per avionics unit	8	.6	.3
$NNAC_I$	Number of new A/C in user category per year	115	Variable	Variable

PARAMETER NAME	DESCRIPTION	COMMERCIAL CARRIER	HIGH PERFORMANCE GENERAL AVIATION	LOW PERFORMANCE GENERAL AVIATION
NOIB	Number different item types stocked at base	8	N/A	N/A
NOID	Number different item types stocked at depot	N/A	N/A	N/A
NPBD	Number pages base level documentation	N/A	N/A	N/A
NPDD	Number pages depot level documentation	N/A	N/A	N/A
$NSRU_J$	Number of SRUs in Jth LRU	Variable	Variable	Variable
NYRS	Number years in life cycle	21	21	21
OFAC	Average time to complete off-A/C maintenance records	0.24 hrs.	0.24 hrs.	0.24 hrs.
ONAC	Average time to complete on A/C maintenance records	0.08 hrs.	N/A	N/A
OSB	Average SRU order/ship time, base (mo.)	0.100 mo.	0.134 mo.	0.134 mo.
OSBL	Average LRU order/ship time, base (mo.)	0.100 mo.	0.134 mo	0.134 mo.
OSD	Average SRU order/ship time, depot (mo.)	N/A	N/A	N/A
OSDL	Average order/ship time, LRU, depot (mo.)	N/A	N/A	N/A
PACK	Packaging factor (packed wt/unpacked wt.)	1.125	1.125	1.125
PFHR	Peak flight hours per month per A/C	264 hrs.	42 hrs.	18.9 hrs.
PMB	Available hours per year per man, base	2,080 hrs.	2,080 hrs.	2,080 hrs.
PMD	Available hours per year per man, depot	2,080 hrs.	2,080 hrs.	2,080 hrs.
PMMH	Average labor-hours per preventive maintenance action	N/A	N/A	N/A
PQTY	Production lot size per manufacturer per year	1,500	3,000	1,500
PRODB	Productivity of base repair personnel	0.86	0.86	0.86
PRODD	Productivity of depot repair personnel	0.86	0.86	0.86

PARAMETER NAME	DESCRIPTION	COMMERCIAL CARRIER	HIGH PERFORMANCE GENERAL AVIATION	LOW PERFORMANCE GENERAL AVIATION
RICOS	Retrofit cost of avionics	11,560	3,770	325
$RMHB_J$	Average labor-hours to remove and replace LRU_J, base	Variable	Variable	Variable
$RTLB_J$	Fraction LRU_J failures repaired at base	Variable	Variable	Variable
RTS_J	Fraction LRU_J failures isolated to SRU at base	Variable	Variable	Variable
$RTSB_{J,K}$	Fraction repairable $SRU_{J,K}$ repaired at base	Variable	Variable	Variable
RTSS	Fraction of failures isolated to LRU at base	1,00	1.00	1.00
SDIST	Percentage markup by distributors on SRUs	0.00	0.30	0.35
SECOB	Support equipment operating cost, base	N/A	$1,440	N/A
SECOD	Support equipment operating cost, depot	$1,440	$1,440	N/A
SHC	Shipping rate, first destination ($/lb.-zone)	$1.37	$1.37	$1.37
$SMTBF_{J,K}$	MTBF of Kth SRU in Jth LRU	Variable	Variable	Variable
$SMTTR_{J,K}$	Mean time to repair $SRU_{J,K}$	Variable	Variable	Variable
SSHC	Shipping rate between base and depot ($/lb.-zone)	$1.37	$1.37	$1.37
STR	Average time to complete supply transaction records	0.25 hrs.	0.25 hrs.	0.25 hrs.
$SUCOS_{J,K}$	Unit cost of $SRU_{J,K}$	Variable	Variable	Variable
SUF(2)	LRU spares sufficiency factor	0.50	0.50	0.50
SUF(3)	SRU spares sufficiency factor	0.50	0.50	0.50
TCOSB	Training cost per base repair person	N/A	N/A	N/A
TCOSD	Training cost per depot repair person	$2,600	N/A	N/A
TFR	Average time to complete transportation forms	0.16 hrs.	0.16 hrs.	0.16 hrs.

PARAMETER NAME	DESCRIPTION	COMMERCIAL CARRIER	HIGH PERFORMANCE GENERAL AVIATION	LOW PERFORMANCE GENERAL AVIATION
TIC	Total number of inventory coded items in stock	8	N/A	N/A
$TNRAC_I$	Number A/C to be retrofit in user category per year	700 (years 1-4)	500	500
TRB	Personnel turnover rate, base	N/A	N/A	N/A
TRD	Personnel turnover rate, depot	0.05	N/A	N/A
UMTBF	MTBF of avionics unit	386.7 hrs.	697.1 hrs.	1,949.7 hrs.
$USECOB_L$	Unit cost of Lth type base support equipment	N/A	$30,000	$20,000
$USECOD_L$	Unit cost of Lth type depot support equipment	$30,000	$30,000	$20,000
$UTILB_L$	Utilization rate, Lth type base support equipment	N/A	0.95	0.95
$UTILD_L$	Utilization rate, Lth type depot support equipment	0.95	0.95	0.95
WT_J	Weight of Jth LRU (lb.)	Variable	Variable	Variable
$WTB_{J,K}$	Weight of Kth SRU in Jth LRU (lb.)	Variable	Variable	Variable
XDIS	Discount rate	0.10	0.10	0.10
XMIL	Average number of shipping zones to first destination	1	1	1
XMINB	Minimum number each type SRU spares per base	1	1	1
XLRN	Learning curve factor	0.875	0.875	0.875
YMIL	Average number of shipping zones between base and depot	1	1	1