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SEA NYMPH PILOT LCC MODEL DEVELOPMENT REPORT.(U)  
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**SEA NYMPH  
Pilot LCC Model  
Development Report**

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## PREFACE

This report was prepared under Project No. A-55-022, "Integrated Logistic Support Planning for Project Sea Nymph," Sponsoring Activity, Naval Electronic Systems Command Headquarters (Code PME-107-1).

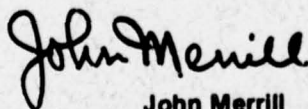
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SEA NYMPH PILOT LCC MODEL  
DEVELOPMENT REPORT

INTRODUCTION

Effective cost management of the Sea Nymph Project requires a dynamic means to (1) identify, (2) define, (3) estimate, (4) calculate, (5) record, (6) evaluate, (7) control, and (8) update cost data. Such data must be processed automatically because of the large number of cost categories (and the factors they consist of) and the necessity to accurately evaluate their effects during project management decision making.

Upon assessment of available and feasible cost information, it has been determined by the Naval Electronics Systems Command Headquarters (NAVELEX) PME 107-1 that the most suitable automatic data processing alternative is the life cycle cost (LCC) method and computer resources. These were developed for the Chief of Naval Material (CNM) by the Naval Weapons Engineering Support Activity (NAVWPNEINGSUPPACT). A description of the basic method to be used is contained in Life Cycle Cost Guide for Equipment Analysis, January 1977, prepared for the Naval Material Command by NAVWPNEINGSUPPACT, Management Engineering Department, Cost Management Division. This report documents LCC application to the Sea Nymph Project and explains practical problems that must be addressed in a typical LCC application.

ORGANIZATION

The principal responsibility for achieving cost information management for the duration of the Sea Nymph Project is assigned to NAVELEX PME 107-11. Engineering assistance is to be provided by organizations that are knowledgeable concerning technical factors affecting project costs. The task of applying the LCC method to the unique needs of the Sea Nymph Project was assigned to the Naval Underwater Systems Center (NUSC). The task of maintaining and updating the LCC Model through the equipment's life cycle will be assigned to NAVWPNEINGSUPPACT. Figure 1 shows the planned organizational relationships.

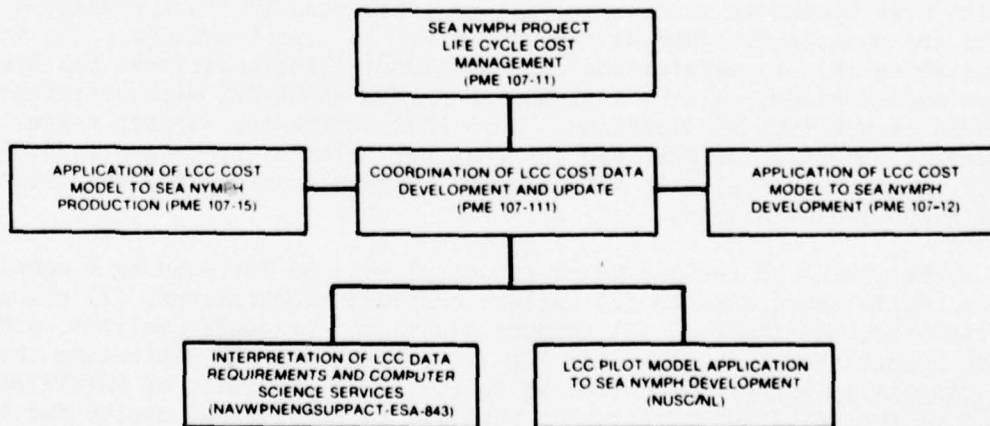


Figure 1. Functional Organization Chart

## IMPLEMENTATION

It is recognized that the LCC model for an equipment is a reflection of the stage of the life cycle that the equipment happens to be in. In the early stages, when operating data have not been accumulated, financial data will be characterized by a degree of uncertainty that will, eventually, diminish. Until actual cost information becomes available, data from similar equipments must be used. This means that the usefulness of the LCC model as an accounting tool is limited, but will gradually increase as specific project data are introduced.

The early LCC model is significant, however, in the logistic support planning area. The use of substitute data is not a serious problem when the intention is to evaluate relative costs of various support system options, such as where to store spare parts and whether to invest in a portable circuit card screener at the intermediate level of maintenance. For tradeoff analyses of this type, relative costs of various options are the primary concern and not the accuracy of the bottom-line value. Thus, the construction of an LCC model during the early stages of the life cycle of the equipment is a direct aid to effective logistic support analysis. The injection of actual data (as the program advances) will enhance the tradeoff studies and improve the LCC model's usefulness as an accounting tool.

Implementation of the LCC for Sea Nymph has been based on the assumption that the model will follow the evolution described above. The task of developing a pilot LCC model has been assigned to NUSC, which will apply expertise gained in the AN/BRD-7 program to generate cost factor data for the pilot model. This model will be oriented toward logistic analysis and provide the timely application required if tradeoff analyses are to be accomplished to influence the Sea Nymph support system development.

Completed negotiations for the Limited Projection contract will begin to provide hard data needed for generating forecasts of actual bottom-line LCCs. Data will come from estimates generated by the contractor in response to LCC tasks incorporated into the statements of work. Some of these costs will be the direct result of the tradeoff analyses to be done on the pilot LCC model. The availability of these data will allow the transformation of the logistics oriented pilot LCC model into a management-oriented model. At the same time, new cost work breakdown structures will be introduced to track project office budgets and maintenance funding forecasts for the Type Commander. The task of accomplishing this transformation and constructing the additional Sea Nymph program modifications will be assigned to NAVWPNEG-SUPPACT with assistance from NUSC on specific applications. This will permit the support system engineering expertise of NUSC and the computer science expertise of NAVWPNEG-SUPPACT to create a realistic LCC product. Figure 2 summarizes the milestones in Sea Nymph implementation.

Establishment of the Sea Nymph LCC model will be followed by a continuing need to update input data to (1) reflect contract negotiations, (2) change projected budget estimates, (3) conduct additional tradeoff analyses, and (4) provide reports for use by NAVLEX PME 107-1 management in presenting the Sea Nymph Program to higher administrative levels. The proximity of NAVWPNEG-SUPPACT to PME 107-1 identifies that activity as the logical choice for long term support of the LCC model.





be the E and N Suites and AN/UYK-20 (which present the bulk of the cost). The only AN/UYK-20 costs included are for procurement of the equipment. In order to derive shipping costs, it is assumed that there are 10 racks of equipment. This configuration has been labeled "Sea Nymph Prime" and it is anticipated that the precision measuring equipment (PME) and fault isolation systems (FIS) will be added to the model after the limited production contract has been negotiated with ESL, Inc.

#### CENTRALIZED DEVELOPMENT

There are a number of hazards that can be avoided when the initial development of an LCC model is undertaken. The tendency of the uninitiated is to address individual cost factors for the model with the intention of combining them into an aggregate that becomes the model. One way of doing this is to assign derivations of individual cost factors to those activities from which the information would normally originate. The hazard here is that two or more activities may have different interpretations of what costs they should include, which causes "double-counting." For example, Sea Nymph will use a 14 rack simulator that will be shipped from Denver to Mountain View. Cost factor BED(E) (transportation cost) includes the cost of shipping equipment to a test site. A supply-oriented activity could easily calculate the cost of this shipment and include it in the generation of a value for BED(E). This would be double-counting because the costs for this shipment were included in the contract for the simulator and, thus, are part of cost factor DS(I) (payment to other contractors), which includes payments\* to others besides the prime contractor during development efforts. Thus, data for this example come from two sources with no certainty that they would coordinate on their own initiative.

A second hazard to be dealt with is the ripple effect that results when a key cost factor is changed; i.e., other factors must then change. For instance, if cost factor PTM (personnel receiving training) is changed, it causes BTS (student travel cost) to change and if different activities are preparing values, the PTM might be based on one assumption and the BTS on another.

The logical means to avoid ripple effects and double-counting is to centralize the development of cost factors and impose a type of configuration control. It is essential that there be a clear understanding of exactly what has been included and excluded in the derivation of each cost factor. This has led to the establishment of cost factor analysis reports, which are being maintained at NUSC and NAVELEX PME 107-1. A sample of such a report and an abbreviated summary sheet including all input data are presented in appendix A.

#### CONTRACTOR DATA INPUTS

A significant number of LCC input factors must originate with the contractor, who in this case will be GTE, Sylvania, for the Sea Nymph Prime and, eventually, ESL, Inc., for the PME and FIS subsystems. Sylvania has proposed construction of a Sea Nymph LCC model using Navy programs on their IBM 370

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\*In this case to the Martin Marietta, Co.

computer. This approach, however, is inappropriate because sensitive program office information that would compromise the Government's contractual negotiating position would have to be used. It would also be inappropriate to provide the contractor with data inputs generated within the Navy because assumptions made in deriving estimated charges for such items as cost factor DT (i.e., the contractor's charge for factory training) might compromise a contractual negotiating position.

The above discussion does not mean that the contractor has no valid role to play in the development of an effective LCC model. There are several dozen cost factors, from the cost of text books to the assignment of factory floor space for depot repairs, that are needed. Many specific costs are not available from existing contracts because negotiations often result in payment of a lump sum for spare parts, engineering services, etc; therefore, the specific amount for a particular item is not identified. There is a resulting need to generate a unique data item for cost factor inputs from the contractor. This will guide the contractor in providing meaningful inputs that can be incorporated directly into the LCC model. A proposed data item description is presented in figure 3.

#### PILOT MODEL APPLICATION

It is intended that the pilot LCC model for Sea Nymph be used to evaluate the relative costs of a number of alternative support approaches. Some of these tradeoffs have been identified and will influence the contents of production contracts; others will be identified as the system evolves. It is correct to envision the Field Maintenance Agent (FMA) using a future iteration of the LCC model to determine which of several alternatives will provide the most cost-effective solution to a support problem on production equipment installed in the Fleet. A list of the tradeoff studies planned as an initial effort is provided in appendix B.

#### TRANSLATION FROM IB TO FLEX 4B COMPUTER PROGRAM

The LCC pilot model currently being developed is a logistic oriented program employing the IB Computer Program prepared by NAVWPENGSUPPACT. This program is sufficient to meet an immediate need for analysis concurrent with the contractor's logistic support analysis (LSA) efforts. The options for support system design that develop from the LSA will be employed in the LCC pilot model. The results will then be used to arrive at fundamental decisions concerning the support system structure.

However, there are some limitations using the IB Computer Program that make it desirable to transfer to the FLEX 4B Computer Program (also developed by NAVWPENGSUPPACT) when possible. The FLEX 4B Program will allow the incorporation of management accounting needs, such as a separate budgeting profile for each of the branches of PME 107-1 and funding projections for external Naval Activities that will be supporting Sea Nymph in the Fleet.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE DATA, LOGISTIC, FOR LIFE CYCLE COST PLANNING	NAVY-EC	UDI-L-223XX
3. DESCRIPTION/PURPOSE THESE DATA DEFINE AND QUANTIFY PROJECT COSTS ASSOCIATED WITH THE ELEMENTS OF INTEGRATED LOGISTIC SUPPORT (ILS).	4. APPROVAL DATE	
	5. OFFICE OF PRIMARY RESPONSIBILITY PME 107	
	6. DDC REQUIRED	
	8. APPROVAL LIMITATION	
7. APPLICATION/INTERRELATIONSHIP THESE DATA PROVIDE COST FACTOR INPUTS TO LIFE CYCLE COST (LCC) MODELS FOR ADVANCED PROGRAM SUPPORT PLANNING.	6. REFERENCES (mandatory as cited in block 10)	
	NAVWPNEGSSUPACT LIFE CYCLE COST GUIDE FOR EQUIPMENT ANALYSIS JANUARY 1977	
MCSL NUMBER		
10. PREPARATION INSTRUCTIONS		
<p>10.1 UNLESS OTHERWISE SPECIFIED IN THE INVITATION FOR BIDS OR REQUEST FOR PROPOSALS, THE DOCUMENTS CITED IN THIS BLOCK (OF THE ISSUE IN EFFECT ON THE DATE OF SUCH INVITATION OR REQUEST) FORM A PART OF THIS DATA ITEM DESCRIPTION (DID) TO THE EXTENT SPECIFIED.</p> <p>10.2 THESE DATA ARE PREPARED BY THE CONTRACTOR IN HIS OWN FORMAT AND CONTAIN THE NEGOTIATED PRICE ASSOCIATED WITH THE CONTRACT STATEMENT OF WORK IN TERMS OF THE LIFE CYCLE COST FACTOR DEFINITIONS OF NAVWPNEGSSUPACT LCC GUIDE (JANUARY 77). THESE COSTS ARE PROJECTED IN TERMS OF GOVERNMENT FISCAL YEARS.</p>		

Figure 3. Proposed Data Item Description

## EXPANSION OF SEA NYMPH PRIME

Sea Nymph Prime was defined in this document as consisting of the E and N Suites and associated AN/UYK-20 Computers. There will be a need to expand this configuration to include AN/USH-24 Wideband Tape Recorders, PME and FIS subsystems, and other "carry-on" equipment. Management at PME 107-1 will determine necessary additional equipment and the scope of the additions on a case basis. For instance, the AN/UYK-20 is part of Sea Nymph Prime but the scope is currently limited to the cost of the machines. Training on the AN/UYK-20 is not addressed, except as part of the E and N Suites factory training. Additional "stand-alone" training may be required. The decision as to whether this is a Sea Nymph cost or one to be shared with other Projects and Commands is the responsibility of NAVELEX PME 107-1.

## PILOT MODEL DEVELOPMENT

### DERIVATION OF COST FACTORS

There are 98 cost factors associated with the LCC Model 1B program (see figure 4) used for the Sea Nymph Pilot Model. The factors are divided into the four basic cost categories of (1) development, (2) acquisition, (3) initial nonrecurring, and (4) recurring. The 98 cost factors are grouped by category in figure 5.

The derivation effort is also organized in terms of four cost factor categories. Specific factors in each category are screened to determine those that have great bearing on the derivation of others. This may take the form of similar background research or it may be that one factor is undefinable until another has been established. The result of the screening is a plan for a sequence of investigations that will build the life cycle cost model efficiently.

It is important to remember that the interpretation of the definition of a cost factor plays a significant role in properly directing the course of the background work. It is insufficient to understand only the definitions of the words used because the application of a factor in the algorithms may change the meaning. For example, travel costs may be interpreted to mean round-trip fares, but the algorithm in the Model 1B LCC multiplies fares by two; therefore, one-way values must be used initially.

### DEVELOPMENT COSTS

Samples of cost breakdown structures and associated cost factors are shown in figure 6. Many of the factors in this category hinge on the derivation of BEP(P), which is the travel cost associated with the training for test and evaluation (T&E). To derive BEP(P), it is necessary to know the following information (which also applies to other cost factor derivations):

DESCRIPTION OF VARIABLES

NAME	NO.	UNITS	DESCRIPTION
RFQ(F)	1	\$/ITEM	COST OF TRANSPORTING SPECIFIC EQUIPMENT FROM CONTRACTOR FACILITY TO TEST SITE
REQ	4	\$/SYSTEM	COST OF TRANSPORTING SYSTEM FROM CONTRACTOR FACILITY TO POINT OF INSTALLATION
REP(P)	1	\$	ONE-WAY TRANSP. COST FOR PERSONNEL RETURN FROM TEST SITE OR HOME STATION AND TEST SITE
RTS	1	\$/PERSON	STUDENT TRAVEL COST FOR INITIAL TRAINING COURSE
RY	1	\$/DIMENSIONLESS	FIRST YEAR DURING WHICH INFLATION-DISCOUNTING OF COSTS WILL OCCUR
CCF AF	1	\$/SQ.FT./YR	ANNUAL COST STANDARD FOR O/I MAINTENANCE SPACE
CCF AS	1	\$/SQ.FT./YR	ANNUAL COST STANDARD FOR DEPOT LEVEL MAINTENANCE SPACE
CU	2	\$/SYSTEM	UNIT PRICE OF ONE OF THE CONTRACTOR'S SYSTEMS
QD	4	\$/PERSON	COST OF STUDENT TEXTS, LEARNING GUIDES AND MANUALS SUPPLIED BY THE CONTRACTOR
OCCT	1	\$	PAYMENT BY GOVERNMENT TO PRIME CONTRACTOR FOR DEVELOPMENT EFFORT DURING YEAR 1
OD	1	\$	ACQUISITION COST OF DATA IF NOT INCLUDED IN ACQUISITION COST OF SYSTEM
ODDS	1	\$	DISMANTLING COSTS INCURRED BY THE GOVERNMENT FOR EQUIPMENT AND MATERIAL REMOVED FROM TEST SITE
ODTS	1	\$	INSTALLATION COSTS INCURRED BY GOV. FOR INSTALLATION OF PROTOTYPE(S) ON DESIGNATED TEST SITE
ODMR	4	\$/ITEM	DPOT MATERIAL COST STANDARD
ODM	4	\$/SYSTEM	COST OF INSTALLATION NOT COVERED BY ACQUISITION COST
ODS	1	\$	ACQUISITION COST OF INITIAL SPARES IF THEY ARE NOT INCLUDED IN SYSTEM ACQUISITION COST
ODFS	1	\$/ITEM	MODIFICATION COSTS INCURRED BY THE GOV. AT A TEST SITE DURING INSTALLATION OF PROTOTYPE SYSTEM
OP	1	RATIO	ANNUAL DISCOUNT RATE FOR FUTURE COSTS
OSCT	1	\$	PAYMENT BY GOVERNMENT TO OTHER CONTRACTORS FOR DEVELOPMENT EFFORT DURING YEAR 1
OSDP	4	\$/ITEM	AVERAGE MATERIAL COST STANDARD FOR O/I MAINTENANCE
OT	4	\$/PERSON	COST OF SPARES TO KEEP SYSTEMS IN OPERATION AND MAINTAIN APPROPRIATE PIPELINE OF REPARABLES
OTCT	1	\$	CONTRACTORS CHARGE FOR STUDENT TRAINING DURING THE INITIAL TRAINING PROGRAM
OTCTE	1	\$/DIMENSIONLESS	COST OF SPECIAL TEST EQUIPMENT
OTG	4	\$/MAN/HR	YEARLY COST ALLOCATION FACTOR FOR DEVELOPING TESTING AND EVALUATION PROGRAM
OTY	4	\$/ALLOCATION	COST TO GOVERNMENT FOR CONDUCTING RECURRING TRAINING COURSES, EXCLUDING THE STUDENT COSTS
OTSCT	1	\$/DIMENSIONLESS	INSTALLATION COST OF TRAINING EQUIPMENT AND MATERIAL
OTU	4	\$/ALLOCATION	YEARLY COST ALLOCATION FACTOR FOR DEVELOPMENT TEST AND EVALUATION TRAINING PROGRAM
F			ACQUISITION COST OF SYSTEM TRAINING AIDS
G			DESIGNATOR FOR SPECIFIC EQUIPMENT - VARIES FROM 1 TO MCF
I			DESIGNATOR FOR SPECIFIC GOVERNMENT FACILITY - VARIES FROM 1 TO NFD
J			DESIGNATOR FOR SPECIFIC GRADE OF CIVILIAN - VARIES FROM 1 TO NDC
K			DESIGNATOR FOR SPECIFIC PROJECT YEAR - VARIES FROM 1 TO Y
L			ANNUAL INFLATION RATE FOR COSTS
LSA(F)	4	\$/SQ.FT./YEAR	MAINTENANCE STORAGE SPACE REQUIRED FOR THE O/I INVENTORY DURING YEAR 1
LSA(S)	4	\$/SQ.FT./YEAR	MAINTENANCE STORAGE SPACE REQUIRED FOR THE DPOT INVENTORY DURING YEAR 1
LY	1	\$/DIMENSIONLESS	YEAR 1 DURING WHICH THE INITIAL/NON-RECURRING COSTS OCCUR
LDPK	4	HOURS/ITEM	DESIGNATOR FOR SPECIFIC SPARE/REPAIR ITEM - VARIES FROM 1 TO MK
LN(T)	4	PERSONS/YEAR	DPOT LABOR TIME STANDARD TO REPAIR
LP(T)	4	PERSONS/YEAR	DESIGNED MAINTENANCE LEVEL FOR O/I SKILLED MAINTENANCE PERSONNEL
LP(M)	4	HOURS/ITEM	DESIGNED MAINTENANCE LEVEL FOR PROFESSIONAL SKILLED MAINTENANCE PERSONNEL
LS(M)	4	HOURS/ITEM	ORGANIZATIONAL LEVEL LABOR TIME STANDARD FOR PREVENTIVE MAINTENANCE
LS(P)	4	HOURS/ITEM	ORGANIZATIONAL LEVEL LABOR TIME STANDARD TO DETECT, ISOLATE, REMOVE AND REPLACE
MSA(F)	4	\$/SQ.FT./YEAR	INTERMEDIATE MAINTENANCE LEVEL LABOR TIME STANDARD TO REPAIR
MSA(S)	4	\$/SQ.FT./YEAR	SPACE REQUIRED FOR O/I MAINTENANCE SHOPS DURING YEAR 1
MSA(M)	4	\$/SQ.FT./YEAR	SPACE REQUIRED FOR DEPOT MAINTENANCE SHOPS DURING YEAR 1

Figure 4. Cost Factors Associated with LCC IB Program

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LIFE CYCLE COST ANALYSIS  
 MOD 1-B  
 NAVAL UNDERWATER SYSTEMS CENTER  
 NEW LONDON LABORATORY, NEW LONDON, CT. (P444)

ANALYSIS IDENTIFICATION AN/HRD-7 DEPOT TEST STATION COST ANALYSIS REPORT

SPONSOR-NAVALEX-PME-107

DESCRIPTION OF VARIABLES

NAME	NO.	UNITS	DESCRIPTION
N(T)	4TN	SYSTEMS	NUMBER OF SYSTEMS IN INVENTORY AT END OF YEAR I
NC	3GNC	COPIES	NUMBER OF COPIES OF TECHNICAL DATA TO BE DISTRIBUTED AND INVENTORIED
NCF	1GNCF	DIMENSIONLESS	TOTAL NUMBER OF EQUIPMENTS & MATERIAL TRANSPORTED FROM CONTRACTORS FACILITY TO PT OF INSTALL
ND	3GND	PAGES	AVERAGE NUMBER OF PAGES PER TECHNICAL MANUAL MAINTAINED BY NAVY
NDGC	1GNDGC	DIMENSIONLESS	TOTAL NUMBER OF CIVILIAN GRADES REQUIRED FOR THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
NDOM	1GNDOM	DIMENSIONLESS	TOTAL NUMBER OF MILITARY RANKS REQUIRED FOR THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
NDP	1GNDP	DIMENSIONLESS	NUMBER OF GOV. PERSONNEL REQUIRED FOR SITE TESTING OF CONTRACTORS SYSTEM
NH(K)	4JNH	HOURS	EXPECTED HOURS THAT KTH ITEM WILL BE USED PER YEAR
NK	4JNK	DIMENSIONLESS	NUMBER OF REPAIRABLE ITEMS IN THE SYSTEMS
NW(T)	2JNW	SYSTEMS	NUMBER OF SYSTEMS ACQUIRED DURING THE TTH YEAR
NW	3JNW	FSN	TOTAL NUMBER OF NEW FSNS TO BE ISSUED ON THE SYSTEM
NW(K)	4JNW(K)	HOURS/ACTION	AVERAGE TIME BETWEEN PREVENTIVE MAINTENANCE ACTIONS FOR ITEM K
NS	1GNS	DIMENSIONLESS	TOTAL NUMBER OF TEST SITES USED DURING THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
NTE	3JNTE	FSN	NUMBER OF NEW FSNS REQUIRED FOR SPECIAL TEST EQUIPMENT FOR SERVICING SYSTEM
NTEF	1JNTEF	DIMENSIONLESS	TOTAL NUMBER OF GOV. FACILITIES REQUIRED DURING DEVELOPMENT PHASE MAINTENANCE TRAINING PROGRAM
NTEU	3JNTEU	LOCATIONS	NUMBER OF LOCATIONS WHICH PROVIDE TRAINING IN MAINTENANCE AND OPERATION OF SYSTEM
P			DESIGNATOR FOR SPECIFIC GOVERNMENT PERSON - VARIES FROM 1 TO 500
PC(G)	1GPC	PERSONS	NUMBER OF ORN SKILLED MAINTENANCE PERSONNEL TO RECEIVE INITIAL TRAINING
PM(R)	1GPM	PERSONS	NUMBER OF PROFESSIONAL SKILLED MAINTENANCE PERSONNEL TO RECEIVE INITIAL TRAINING
PO	4JPO	PERSONS/SYSTEMS	DESIGNATOR FOR SPECIFIC MILITARY RANK - VARIES FROM 1 TO 5000
PSOS	4JPSOS	SG-ET/SYSTEM	NUMBER OF OPERATING PERSONNEL REQUIRED PER SYSTEM
PTM	3JPTM	PERSONS/YR	FLOOR SPACE REQUIRED FOR THE OPERATION OF PRIME SYSTEM
PTP	3JPTP	PERSONS/YR	NUMBER OF MILITARY PERSONNEL OF GRADE G REQUIRED DURING DEV. PHASE TEST AND EVAL. MAINT. PROGRAM
R			NUMBER OF OPERATING PERSONNEL REQUIRED PER SYSTEM
R(K)	4JR	HOURS/FAILURE	MEAN TIME BETWEEN FAILURES FOR ITEM K
RAM	4JRAM	RATIO	TURNOVER RATE FOR ORN SKILLED MAINTENANCE PERSONNEL
REP	4JREP	RATIO	TURNOVER RATE FOR PROFESSIONAL SKILLED MAINTENANCE PERSONNEL
RC(G)	1GRC	\$/MAN/DAY	DAILY COST RATE FOR CIVILIAN PERSONNEL OF GRADE G
ROL	4JROL	\$/MAN/HOUR	AVERAGE DEPOT LABOR RATE TO REPAIR FAILED ITEMS
REF(F)	1REF	\$/FACILITY DAY	DAILY COST RATE FOR GOVERNMENT FACILITY
RFM	3JRFM	\$/PAGE/YR	ANNUAL COST PER PAGE OF TECHNICAL DATA FOR FILE MAINTENANCE
RIE	3JRIE	\$/FSN	ITEM ENTRY COST INTO THE FEDERAL STOCK SYSTEM
RIP	4JRIE	\$/FSN/YR	ANNUAL ITEM RETENTION COST IN THE FEDERAL STOCK SYSTEM
RM(R)	1CRM	\$/MAN/DAY	DAILY COST RATE FOR MILITARY PERSONNEL OF LEVEL R
RO	4JRO	\$/MAN/YR	AVERAGE ANNUAL COST FOR SYSTEM OPERATIONS PERSONNEL
RP	3JRP	\$/PAGE/COPY	COST PER PAGE FOR INITIAL REPRODUCTION AND DISTRIBUTION OF TECHNICAL DATA
RPL	4JRPL	\$/POUND	STANDARD PACKING LABOR RATE
RRM	4JRRM	\$/POUND	STANDARD PACKING MATERIAL RATE
RSL	4JRSL	\$/MAN/HOUR	AVERAGE ORGANIZATION AND INTERMEDIATE MAINTENANCE LABOR RATE TO REPAIR FAILURE ITEMS
RSD(S)	1CRSD	\$/SITE/DAY	AVERAGE DAILY OPERATING COST FOR NORMAL OPERATIONS OF A TEST SITE
RSE	4JRSR	\$/POUND	AVERAGE SHIPPING RATE
RSR	4JRSR	RATIO	FRACTION OF FAILURES REPAIRED AT THE INTERMEDIATE MAINTENANCE LEVEL
RSS(K)	4JRSS	\$/MAN/FEK	AVERAGE WEEKLY STUDENT PAY AND ALLOWANCE RATE DURING THE ORN COURSE
RTM	3JRTM	\$/MAN/WEEK	AVERAGE WEEKLY STUDENT PAY AND ALLOWANCE RATE DURING THE PROFESSIONAL MAINTENANCE COURSE
RTP	3JRTP	DIMENSIONLESS	RATIO OF PACKAGED TO THE UNPACKAGED WEIGHT
RW(K)	4JRW	DIMENSIONLESS	

Figure 4. (Cont'd) Cost Factors Associated with LCC IB Program

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FACTORS ASSOCIATED WITH DEVELOPMENT COST

BY	DC(I)	DR	IR	IYI	Y
BED(E)	BEP(P)	DDD(S)	DDI(S)	DM(S)	DTES(I)
NCF	NDOC	NDOM	NDP	NS	PC(G)
PM(R)	RC(G)	RM(R)	RSO(S)	TDO(S)	DS(I)
DTS(I)	NTFD	RF(F)	TTDC	TTDM	TTFD(F)

FACTORS ASSOCIATED WITH ACQUISITION COSTS

CU	NN(I)
----	-------

FACTORS ASSOCIATED WITH INITIAL/NONRECURRING COSTS

BTS	DTI	NTU	PTP	RTP	DIS
ND	RP	NC	NTEN	DT	DTU
PTM	TRM	TTL	NNI	RFM	DD
RIE					

FACTORS ASSOCIATED WITH RECURRING COSTS

DIM	BOE	DB	DTG	LM(I)	LP(I)
RAM	RAP	DSP(I)	RIM	DTE(I)	CSFAF
CSFAS	N(I)	PO	PSOS	RO	NK
NPM(K)	R(K)	RDL	RPL	RPM	RSL
RSR	RSS(K)	RW(K)	W(K)	DDM(K)	DSM
ISAF(I)	LDR(K)	LPM(K)	LSD(K)	LSR(K)	MSAF(I)
MSAS(I)	NH(K)	ISAS(I)			

DESIGNATORS

E	F	G	I	K	P
R	S				

Figure 5. Cost Factors by Category



WBS	FUNCTION	COST FACTORS INVOLVED
110 000	PAYMENT BY GOVERNMENT TO PRIME CONTRACTOR FOR SYSTEM DEVELOPMENT EFFORT	DC(I)
120 000	PAYMENT BY GOVERNMENT TO OTHER THAN PRIME CONTRACTOR FOR SYSTEM DEVELOPMENT EFFORT	DS(I)
131 110	MILITARY PAY AND ALLOWANCE COSTS DURING MAINTENANCE TRAINING FOR T&E EFFORT	DTS(I) NDOM TTDM PM(R) RM(R)
131 120	CIVILIAN PAY AND ALLOWANCE COSTS DURING MAINTENANCE TRAINING FOR T&E EFFORT	DTS(I) NDOC TTDC PC(G) RC(G)
131 200	GOVERNMENT FACILITY COSTS INCURRED DURING T&E EFFORT	DTS(I) NTFD TTFD RF(F)
132 110	TEST SITE MODIFICATION COSTS INCURRED DURING T&E EFFORT	DTES(I) NS DM(S)
132 120	PROTOTYPE INSTALLATION COSTS AT T&E TEST SITES	DTES(I) NS DDI(S)
132 130	TEST SITE OPERATION COSTS DURING T&E EFFORT	DTES(I) NS TDO(S) RSO(S)
132 140	TEST SITE RESTORATION COSTS AFTER CONCLUSION OF T&E EFFORT	DTES(I) DDD(S)
132 210	MILITARY PAY AND ALLOWANCES INCURRED DURING T&E EFFORT	DTES(I) NDOM NS PM(R) RM(R) TDO(S)
132 220	CIVILIAN PAY AND ALLOWANCES INCURRED DURING T&E EFFORT	DTES(I) NS RC(G) PC(G)
132 300	TRAVEL COSTS INCURRED DURING TRAINING FOR T&E EFFORT	DTES(I) NDP BEP(P)
132 400	TRANSPORTATION OF MATERIAL COSTS FROM CONTRACTOR TO TEST SITE DURING T&E EFFORT	DTES(I) NCF BED(E)

Figure 6. Development Cost Work Breakdown Structures

1. number of training sites,
2. ranks of students and instructors,
3. number of students,
4. number of instructors,
5. course length,
6. car rental fees,
7. plane fares,
8. per diem costs, and
9. number of classes.

When these costs have been defined many other cost factors will also have been because of overlapping and parallel research. Specifically, defining the training sites identifies the following cost factors:

1. S -- the designator for the specific test site and
2. NS -- the total number of test sites during development.\*

When defining the number of personnel involved with development T&E (as an input to the BEP(P) derivation) the following cost factors are identified:

1. NDOC -- the pay grades of civilian T&E personnel,
2. NDP -- the number of government personnel involved with site testing and training,
3. PC(G) -- the number of civilians of each pay grade involved with T&E,
4. PM(R) -- the number of military of each rank involved in T&E, and
5. NDOM -- the number of military ranks involved with T&E.

When determining the number and length of training and testing periods for BEP(P), the basic information exists to define the following cost factors:

1. DTS(I) -- the yearly cost allocation by year for T&E training,
2. TTFD(F) -- the number of days the training facility is used during T&E, and
3. TDO(S) -- the number of days the test site is used for T&E.

---

\*The initial training and the test site were at the same location for Sea Nymph application.

In a similar fashion, the basic information for the following cost factors are derived in the process of generating the derivation of BEP(P):

1. DTES(I) -- the yearly cost allocation by year for T&E effort,
2. TTDM -- the military training days during T&E
3. NTFD -- the number government facilities required during T&E, and
4. TTDC -- the civilian training days required during T&E.

The family of cost factors associated with BEP(P) leads to the derivation of other cost factors in a logical progression that is illustrated in figure 7. This process can be applied to the three other cost factor categories.

ALGORITHM IMPACT

As was mentioned earlier, it is insufficient to rely on language to determine what a cost factor will be used for because the algorithm may impose additional interpretations or restrictions. Furthermore, it is important to understand how to express the cost factor as input data to the computer software. Two examples of this in the Sea Nymph derivation are

1. PM(R) -- the number of military personnel of rank R required during the development phase of the T&E maintenance program and
2. RM(R) -- the daily cost rate for military personnel of rank R.

These cost factors are used in Cost Breakdown Structure CBS 132 210, for which military personnel pay and allowance costs incurred during the T&E maintenance program are calculated according to the following algorithm:

$$\begin{matrix} \text{Annual} & & \text{Days in} & & \text{Number} & & \text{Daily} \\ \text{Allocation} & * & \text{Testing} & * & \text{of} & * & \text{Pay} \\ \text{Factor} & & \text{Period} & & \text{Personnel} & & \text{Rate} \end{matrix}$$

or

$$\sum_{I=1}^Y \text{DTES}(I) \sum_{S=1}^{NS} \text{TDO}(S) \sum_{R=1}^{NDOM} \text{PM}(R) * \text{RM}(R) ,$$

where

NDOM = total number of military ranks required for the T&E development phase,

R = designator for specific military rank (form 1 to NDOM)

DTES(I) = yearly cost allocation for T&E development phase, and

TDO(S) = number of days a test site is used during T&E development.



Table 1 shows the number of military personnel involved with the T&E development programs, i.e., a total of 5 ranks, or  $PM(R) = 5$ .

Table 1. EDM Test and Evaluation Military Ranks

T&E Program	ET-2	ET-1	ETC	04	05
EDM Training for OT-IIIA	2	2	1	1	1
OT-IIIA	2	2	1	1	1
EDM Training for OT-IIIB	2	2	1	1	1
OT-IIIB	2	2	1	1	1
OT-IIIC	2	2	1	1	1

However, cost factor  $PM(R)$  must be expressed differently to satisfy programming requirements. The  $PM(R)$  must be factored such that there are two ranks with a population of two and three ranks with a population of one. Thus  $PM(R) = 5$  becomes  $(2)(2) + (3)(1)$ , where the computer first addresses the ranks having a value of two and then addresses those having a value of one. It should be noted that this software procedure may vary according to the computer used.

In the case of  $RM(R)$ , the daily pay rates for the five military ranks given in table 1 are:

1. ET-2 (4 years longevity) = \$18.61
2. ET-1 (6 years longevity) = \$21.85
3. ETC (10 years longevity) = \$26.28
4. 05 (10 years longevity) = \$50.20
5. 04 (10 years longevity) = \$48.26

The original value for  $RM(R)$  was calculated to be the mean value of the above rates. However, the input to the computer is expressed in terms of the individual values, i.e.,

$$RM(R) = 18.61, 21.85, 26.28, 48.26, 50.20$$

#### COMPUTER APPLICATION

##### COMPATIBILITY OF DATA AND ALGORITHMS

As was stated earlier, the LCC model cost factors must reflect the situation for a specific project while remaining compatible with the algorithms of the software program. It is sometimes necessary to restructure

data or use an approximation to achieve compatibility with algorithms that have been structured to fit many projects. As a result, there is a requirement to screen the cost factor derivations that are prepared for compatibility. This may result in an iterative process in which changes to make one derivation compatible may trigger a ripple through other cost factor derivations.

The LCC 1B Computer Software Program has, in its current state, limitations relative to certain allowable magnitudes exceeded during Sea Nymph derivation efforts. Cost factor BEP(P), a subscripted variable, was computed to be \$58,041.32 for the one-way transportation costs associated with military and civilian personnel traveling to and from the T&E site. The algorithm (WBS 132 300) in which BEP(P) appears defines this cost factor as

WBS 132 300

$$\sum_{I=1}^Y \text{DTES}(I) \sum_{P=1}^{\text{NDP}} * 2 * \text{BEP}(P) ,$$

where

BEP(P) = one-way travel costs,

NDP = number of personnel, and

DTES(I) = fraction of total costs occurring each year.

The resultant value is then multiplied by two to yield round-trip travel costs for each year.

However, the upper limit for the value of BEP(P) in the 1B Computer Software Program is \$9,999.99. The adjustment is accomplished by dividing BEP(P) by 11 to yield 5,276.48, which is within the upper limit. Therefore, when BEP(P) is applied in the software program it becomes (5,267.48)(11) and the costs are summed across the range of NDP, as indicated by the algorithm. This approach permits the computer to perform correctly.

#### COMPUTATION OF ALGORITHMS

The 98 cost factor values that have been derived are loaded by card deck and used for computation of algorithms associated with the cost breakdown structures. A sample of the computed values is provided in figure 8. A typical computation is CBS 471 100 (cost of maintenance labor), which has the following algorithm:

$$N(I) \sum_{K=1}^{\text{NK}} \text{NH}(K) * \text{LSD}(K) * \text{RSL} \div \text{R}(K) ,$$

LIFE CYCLE COST ANALYSIS  
 MOD 1-R

NAVAL UNDERWATER SYSTEMS CENTER  
 NEW LONDON LABORATORY, NEW LONDON, CT. (PAR4)

SPONCOR=NAVALEX-PME-107

ANALYSIS IDENTIFICATION AN/PRR-7 DEPOT TEST STATION COST ANALYSIS REPORT

INFLATION = -0.8, DISCOUNT = -0.8, BASE YEAR = 1

COST BREAKDOWN STRUCTURE REPORT

\$\$\$ COSTS IN THOUSAND DOLLARS \$\$\$	COST BREAKDOWN STRUCTURE ELEMENT	TOTAL ADJUSTED COST	<---PERCENTS OF TOTAL ADJUSTED COST--->
124000	AIDS	9262.50	1.6
124100	ACQUISITION	9000.00	1.6
124200	INSTALLATION	262.50	.3
130000	SUPPLY SUPPORT	150.00	.0
131000	ACQUISITION OF INITIAL SPARES	.00	.0
132000	INTRODUCTION INTO THE SUPPLY SYSTEM	150.00	.0
132100	NEW FSMS IN PRIME SYSTEM	150.00	.0
132200	NEW FSMS IN SUPPORT EQUIPMENT	.00	.0
400000	RECURRING	153871.50	27.2
410000	PRIME SYSTEM	4460.86	.6
411000	TRANSPORTATION TO INSTALLATION SITE	160.86	.0
412000	INSTALLATION	4300.00	.6
420000	TECHNICAL DATA MAINTENANCE	1353.14	.2
430000	SUPPLY SUPPORT	47765.00	8.5
431000	FSN MAINTENANCE	650.00	.1
431100	PRIME SYSTEM	650.00	.1
431200	SUPPORT EQUIPMENT	.00	.0
432000	ACQUISITION OF REPLACEMENT SPARES	47135.00	8.3
440000	TRAINING	2690.77	.2
441000	PAY AND ALLOWANCES (NAVY PERSONNEL)	881.88	.0
441100	PROFESSIONAL COURSE	.00	.0
441200	OPERATING AND MAINTENANCE COURSE	881.88	.2
442000	COURSE MATERIAL	988.87	.0
442100	PROFESSIONAL COURSE	.00	.0
442200	OPERATING AND MAINTENANCE COURSE	988.87	.2
443000	COURSE FEE	824.41	.1
443100	PROFESSIONAL COURSE	.00	.0
443200	OPERATING AND MAINTENANCE COURSE	824.41	.1
450000	ACQUISITION OF SUPPORT + TEST EQUIP OPERATIONS	32529.50	.0
461000	PERSONNEL PAY AND ALLOWANCES	22171.22	3.9
462000	FACILITY SPACE	10358.28	1.8
470000	MAINTENANCE	65002.20	1.7
471000	LAPOR	9323.38	.2
471100	ORGANIZATIONAL (REPLACE)	1227.56	.1
471200	INTERMEDIATE (REPAIR)	491.03	.1
472000	REPAIR MATERIAL	7638.75	1.3
472100	INTERMEDIATE	44927.50	8.0
		8985.50	1.6

Figure 8. Output Reports Generated by 1B Program

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where

$$NK = 1$$

$$NH = 4100$$

$$LSD = 0.5$$

$$RSL = 14.36$$

$$R(K) = 10$$

$$N(I) = 3*0,5,12,22,34,8*43,$$

which, when applied to the algorithm, yields

$$(4100)(0.5)(14.36) \div (10) = 2943.8 .$$

Then, the summation of costs for the 15 year life cycle are

$$N(I) \sum_{K=1}^{NK} (3)(0) + (5)(2943.8) + (12)(2943.8) + (22)(2943.8) \\ + (34)(2943.8) + (344)(2943.8) = 1227.564K .$$

This is the value shown for CBS 471 100 in figure 8.

#### COMPUTER OUTPUT REPORTS

Figure 8 also provides an example of the output reports generated by the LCC 1B Computer Program. They are the (1) summary, (2) cost breakdown structure, (3) general funding, and (4) annual cost by category (see figures 9 through 12, respectively). The use of the reports can be demonstrated by selecting cost breakdown structure CBS 132 200 and tracing its impact through each of them. The CBS 132 300 is concerned with travel costs and its algorithm employs the following costs factors:

1. BEP(P) -- the one way transportation costs during the T&E phase,
2. NDP -- the number of government personnel involved in T&E, and
3. DTES(I) -- the annual allocation of development testing and evaluation.

For this example, the values will be

1. BEP(P) = 11\* 5276.48363,
2. NDP = 11, and
3. DTES = 0, .1, .15, .5, .25, 10\*0



NAVAL UNDERWATER SYSTEMS CENTER  
NEW LONDON LABORATORY, NEW LONDON, CT. (R444)

ANALYSIS IDENTIFICATION AN/PRC-7 DEPOT TEST STATION COST ANALYSIS REPORT

SPONSOR-NAVALEX-PRE-107

SUMMARY

\$\$\$ COSTS IN THOUSAND DOLLARS \$\$\$ INFLATION = 0% DISCOUNT = 0% BASE YEAR = 1

COST CATEGORY	#	DEVELOPMENT	#	ACQUISITION	#	INITIAL	#	RECURRING	#	CATEGORY TOTAL
PRIME CONTRACTOR		16200.00		.00		.00		.00		16200.00
% OF COST CATEGORY TOTAL		100.0		.0		.0		.0		100.0
% OF COST ELEMENT TOTAL		29.8		.0		.0		.0		2.8
OTHER CONTRACTOR		36516.00		.00		.00		.00		36516.00
% OF COST CATEGORY TOTAL		100.0		.0		.0		.0		100.0
% OF COST ELEMENT TOTAL		68.0		.0		.0		.0		6.5
TESTING		592.63		.00		.00		.00		592.63
% OF COST CATEGORY TOTAL		100.0		.0		.0		.0		100.0
% OF COST ELEMENT TOTAL		1.1		.0		.0		.0		.1
PRIME SYSTEM		.00		344070.00		.00		4460.86		348460.86
% OF COST CATEGORY TOTAL		.0		98.7		.0		1.3		100.0
% OF COST ELEMENT TOTAL		.0		100.0		.0		2.9		61.7
TRAINING		630.14		.00		11001.54		2690.77		14322.45
% OF COST CATEGORY TOTAL		6.8		.0		76.6		18.6		100.0
% OF COST ELEMENT TOTAL		1.2		.0		42.3		1.7		2.5
SUPPLY SUPPORT		.00		.00		150.00		47795.00		47935.00
% OF COST CATEGORY TOTAL		.0		.0		.5		99.7		100.0
% OF COST ELEMENT TOTAL		.0		.0		1.1		11.1		8.5
TECHNICAL DATA		.00		.00		2216.56		1353.16		3569.73
% OF COST CATEGORY TOTAL		.0		.0		62.1		37.9		100.0
% OF COST ELEMENT TOTAL		.0		.0		16.6		.9		.6
SUPPORT EQUIPMENT		.00		.00		.00		.00		.00
% OF COST CATEGORY TOTAL		.0		.0		.0		.0		100.0
% OF COST ELEMENT TOTAL		.0		.0		.0		.0		.0
OPERATION		.00		.00		.00		32529.50		32529.50
% OF COST CATEGORY TOTAL		.0		.0		.0		100.0		100.0
% OF COST ELEMENT TOTAL		.0		.0		.0		21.1		5.8
MAINTENANCE		.00		.00		.00		65002.20		65002.20
% OF COST CATEGORY TOTAL		.0		.0		.0		100.0		100.0
% OF COST ELEMENT TOTAL		.0		.0		.0		42.3		11.5
COST ELEMENT TOTAL		53738.77		344000.00		13368.10		153821.50		544928.36
% OF LIFE CYCLE COST		9.5		60.9		2.4		27.2		100.0

Figure 9. Summary Report

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LIFE CYCLE COST ANALYSIS  
 MOD 1-R

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 NEW LONDON LABORATORY, NEW LONDON, CT. (RANR)

SPONSOR-NAVALEX-PME-1U7

ANALYSIS IDENTIFICATION AN/RRN-7 DEPOT TEST STATION COST ANALYSIS REPORT  
 COST BREAKDOWN STRUCTURE REPORT

INFLATION= .0% DISCOUNT= .0% BASE YEAR= 1

\$\$\$ COSTS IN THOUSAND DOLLARS \$\$\$

TOTAL ADJUSTED COST  
 <---PERCENTS OF TOTAL ADJUSTED COST--->  
 < FOR TOTAL LIFE CYCLE >

BREAKDOWN STRUCTURE NUMBER	COST BREAKDOWN STRUCTURE ELEMENT	TOTAL ADJUSTED COST	PERCENTS OF TOTAL ADJUSTED COST	PERCENTS OF TOTAL ADJUSTED COST FOR TOTAL LIFE CYCLE
000000	TOTAL LIFE CYCLE	568926.76		100.0
100000	DEVELOPMENT	53738.77		9.5
110000	PRIME CONTRACTOR	16000.00		2.8
120000	OTHER CONTRACTOR	36516.00		6.5
130000	GOVERNMENT	1222.77		.2
140000	TRAINING	639.14		.1
150000	PAY AND ALLOWANCES	5.74		.0
160000	MILITARY	5.14		.0
170000	CIVILIAN	.00		.0
180000	FACILITIES	625.00		.1
190000	PROTOTYPE TESTING	592.63		.1
200000	TEST SITE	406.62		.1
210000	NOTIFICATION OF PROTOTYPE SYSTEM	.00		.0
220000	INSTALLATION OF TEST SITE	.00		.0
230000	OPERATION OF TEST SITE	406.62		.1
240000	RESTORATION	.00		.0
250000	PAY AND ALLOWANCES	69.42		.0
260000	MILITARY	25.71		.0
270000	CIVILIAN	43.71		.0
280000	TRAVEL	116.00		.0
290000	TRANSPORTATION OF MATERIAL	.50		.0
300000	ACQUISITION OF PRIME SYSTEMS	140000.00		60.9
310000	INITIAL TECHNICAL DATA	13368.10		2.8
320000	ACQUISITION	2216.56		.4
330000	REPRODUCTION AND DISTRIBUTION	2133.80		.4
340000	FIRST YEAR MAINTENANCE	112.76		.0
350000	TRAINING	11301.54		1.9
360000	PAY AND ALLOWANCES	235.42		.0
370000	PROFESSIONAL	53.74		.0
380000	OPERATING AND MAINTENANCE	181.68		.0
390000	TRAVEL	673.45		.1
400000	PROFESSIONAL	62.89		.0
410000	OPERATING AND MAINTENANCE	607.96		.1
420000	CONTRACTOR SUPPORT	832.77		.1
430000	PROFESSIONAL	78.37		.0
440000	OPERATING AND MAINTENANCE	758.70		.1

Figure 10. Cost Breakdown Structure

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NAVAL UNDERWATER SYSTEMS CENTER  
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SPONSOR-NAVALEX-PME-107

ANALYSIS IDENTIFICATION AN/RQD-7 DEPOT TEST STATION COST ANALYSIS REPORT

ANNUAL COST BY COST CATEGORY

\$\$\$ COSTS IN THOUSAND DOLLARS \$\$\$ INFLATION: -0% UNDISCOUNTED\*BASE YEAR= 1

BASE YEAR	PRIME CONTRACTOR	OTHER CONTRACTOR	TESTING	PRIME SYSTEM	TRAINING	SUPPLY SUPPORT	TECHNICAL DATA	SUPPORT EQUIPMENT	OPERATION	MAINTENANCE	TOTAL
1	4000.	4512.	0.	0.	630.	0.	0.	0.	0.	0.	9142.
CUM.	4000.	4512.	0.	0.	630.	0.	0.	0.	0.	0.	9142.
2	4000.	4350.	59.	0.	0.	0.	0.	0.	0.	0.	8409.
CUM.	8000.	8862.	59.	0.	630.	0.	0.	0.	0.	0.	17551.
INITIAL YEAR 3	4100.	4030.	89.	0.	1132.	200.	2217.	0.	0.	0.	21587.
CUM.	12000.	12892.	148.	0.	11632.	200.	2217.	0.	0.	0.	39136.
4	4000.	5456.	296.	40519.	0.	50.	113.	0.	266.	980.	51580.
CUM.	16000.	18348.	444.	40519.	11632.	250.	2329.	0.	266.	980.	90718.
5	0.	5332.	148.	56726.	245.	4335.	113.	0.	638.	2300.	69837.
CUM.	16000.	23680.	593.	97245.	11876.	4565.	2442.	0.	908.	3281.	160556.
6	0.	3092.	0.	81037.	285.	4335.	333.	0.	3370.	4133.	94124.
CUM.	16000.	26772.	593.	178282.	12121.	8923.	2555.	0.	2074.	7413.	254680.
7	0.	3244.	0.	97245.	285.	4335.	113.	0.	1808.	6182.	113191.
CUM.	16000.	29986.	593.	275527.	12366.	13255.	2668.	0.	3881.	13596.	367871.

Figure 12. Annual Cost by Category

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and applied in

$$\sum_{I=1}^Y DTES(I) \sum_{P=1}^{NDP} * 2 * BEP(P)$$

yields, for Y=15 years,

$$\sum_{I=1}^Y 0, 0.1, 0.15, 0.24, 10*0, \sum_{P=1}^{NDP} 11 * 5276.483 * 2 .$$

This shows that costs are spread over the second, third, fourth, and fifth years and are summed to a maximum of 11 civilian employees involved in the T&E effort. The yearly costs for transportation are shown in table 2.

Table 2. Yearly Transportation Cost

Year	Allocation Factor	Cost
2	0.10	\$11,608.263
3	0.15	\$17,412.395
4	0.50	\$58,041.315
5	0.25	\$29,020.658

Total \$116,082.631

These costs appear in the summary report (see figure 9) as part of the development and testing cost total, which is \$592.63K. This represents 1.1 percent of the total development costs (listed at the bottom of the column as \$58,738.77K\*). This value, in turn, represents 9.5 percent of the total life cycle cost, which appears in the lower right-hand corner

The transportation costs appear in the cost breakdown structure report (see figure 10) under the general category of prototype testing, which is CBS 132 000. There are ten subcategories, each with its own computation. The CBS 132 300 appears with a value of 116.08. The general funding report (figure 11) shows CBS 132 300 as travel cost having a value of 116. The annual cost by category (figure 12) shows that by year five, the aggregate total testing costs has reached \$593K, including the \$116K for transportation.

TYPICAL SENSITIVITY ANALYSIS

An important feature of the LCC model is the capability to inject a range of values for a given cost factor (while all other factors remain constant)

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\*Values do not always precisely coincide because of rounding during computation.

and generate a set of total LCC factors. This allows determination of the cost factors having the greatest impact on the total LCC factors.

Figure 13 provides an example of how the sensitivity analysis may be used. A preliminary life cycle run is depicted in which the system mean time between failures (MTBF) for cost factor R was varied by a range of 50 percent. The results shown in figure 10 are plotted in figure 14 where it can be seen that, for this hypothetical case, the impact on costs is nonlinear and that the nonlinearity becomes significant beyond the range of 20 percent. It can also be seen that an engineering change proposal (ECP) that would increase system MTBF by 10 percent would not be cost-effective (if the price of the proposal were in the \$5M area).

#### SUMMARY

The development of a life cycle cost model can be helpful to the acquisition manager in making decision concerning to support. It is possible to use LCC to justify decisions on the basis of cost-effectiveness, as long as it is understood that LCC is not a highly-accurate cost accounting system. Instead, it is a tool for evaluating the relative costs of various support options.

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LIFE CYCLE COST ANALYSIS  
 MOD 1-B

DATE 7/19/77  
 PAGE 9-002

NAVAL UNDERWATER SYSTEMS CENTER  
 NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

SPONSOR-NAVALEX-PME-107

ANALYSIS IDENTIFICATION AN/RRD-7 DEPOT TEST STATION COST ANALYSIS REPORT

SENSITIVITY ANALYSIS

INFLATION= .08\*DISCOUNT= .08\*BASE YEAR= 1

\$\$\$ COSTS IN THOUSAND DOLLARS \$\$\$

SENSITIZED VARIABLE: R MEAN TIME BETWEEN FAILURES FOR ITEM K

SEN- NUM- BASE	MULTIPLIER	DEVELOPMENT	ACQUISITION	COST ELEMENT	INITIAL	RECURRING	TOTAL LIFE CYCLE
1	1.00	53738.77	344000.00	13368.10	153821.50	564928.36	
2	.50	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	210734.21(-37.00)	621841.08(-10.07)	
3	.60	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	193763.31(-24.67)	602870.17(-6.72)	
4	.70	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	178212.66(-15.86)	589319.53(-4.32)	
5	.80	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	168049.68(-9.25)	579156.54(-2.52)	
6	.90	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	160145.13(-4.11)	571252.00(-1.12)	
7	1.00	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	153821.50(-.00)	564928.36(-.00)	
8	1.10	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	148847.62(-3.36)	559754.88(-.92)	
9	1.20	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	144336.05(-6.17)	555442.91(-1.68)	
10	1.30	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	140687.80(-8.54)	551794.66(-2.32)	
11	1.40	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	137560.72(-10.57)	548667.59(-2.88)	
12	1.50	53738.77(-.00)	344000.00(-.00)	13368.10(-.00)	134850.60(-12.33)	545957.46(-3.36)	

MATRIX OF VALUES FOR THE ABOVE SENSITIVITY ANALYSIS

ARRAY INDEX	RASIC VALUE	1	2	3	4	5	6	7	8	9	10	11
1	.17+002	.50+001	.60+001	.70+001	.80+001	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002
2	.50+001	.60+001	.70+001	.80+001	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002	
3	.60+001	.70+001	.80+001	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002		
4	.70+001	.80+001	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002			
5	.80+001	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002				
6	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002					
7	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002						
8	.11+002	.12+002	.13+002	.14+002	.15+002							
9	.12+002	.13+002	.14+002	.15+002								
10	.13+002	.14+002	.15+002									
11	.14+002	.15+002										
12	.15+002											

R - PERCENT CHANGE FROM BASE VALUE

9FIN

Figure 13. Sensitivity Analysis Use

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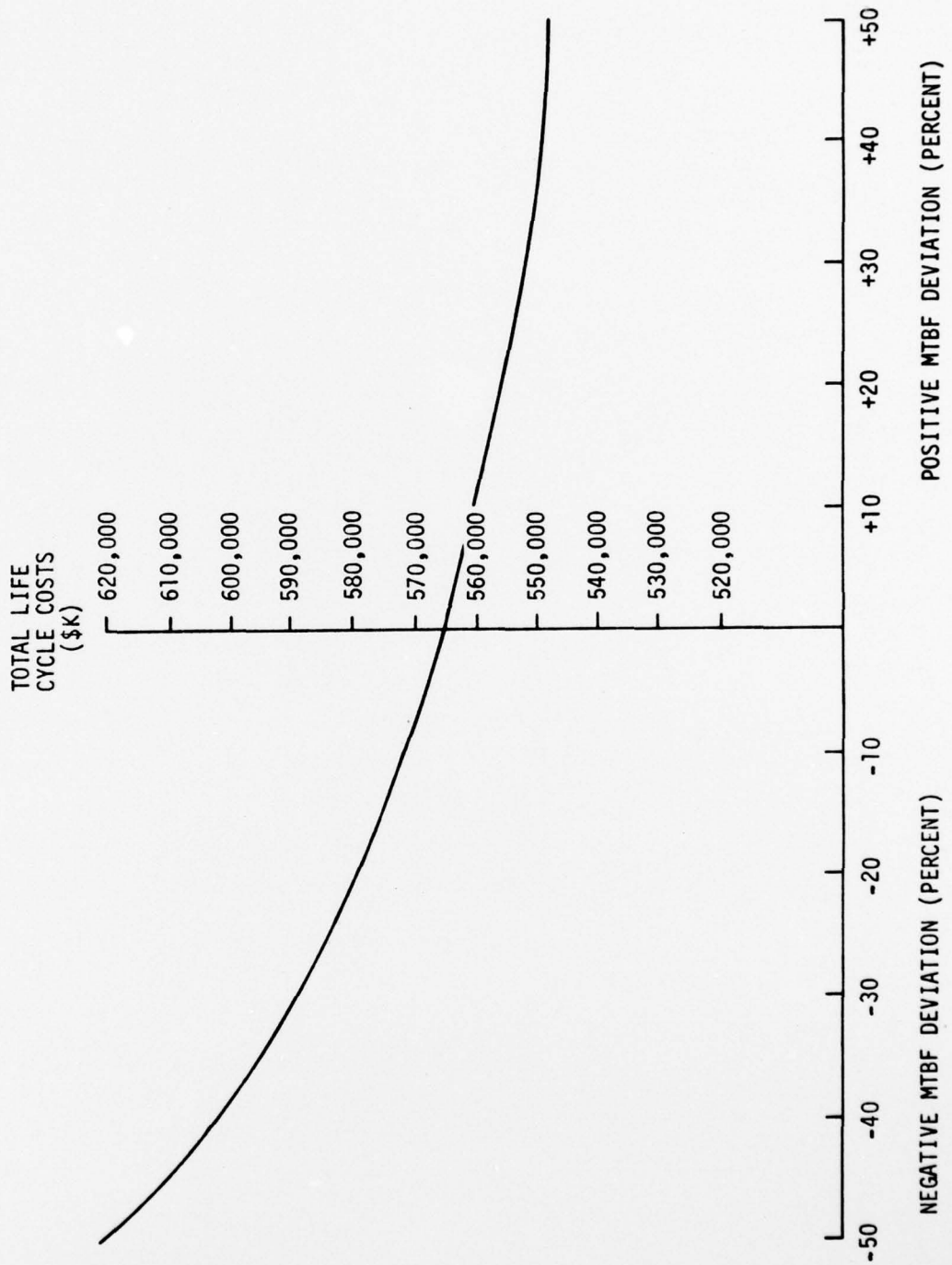


Figure 14. Cost Breakdown Plot



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Life Cycle Cost Methodology For Government Furnished Equipment, Naval Weapons Engineering Support Activity (NAVWPNEINGSUPPACT) (Code 843), Washington Naval Shipyard, Washington DC 20374, March 1975.

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Appendix A  
COST FACTOR ANALYSIS REPORTS

LIFE CYCLE COST FACTOR - BTS (Units = \$/man)

1. PROGRAM - SEA NYMPH PRIME

SEA NYMPH PRIME is identified as a Unit comprised of ten (10) Electronic Hardware Racks of equipment for which the BTS cost factor must be established.

2. DEFINITION - BTS

Student travel cost will be a round trip fare. The travel cost shall be provided for military and civilian (exempt and non-exempt) personnel.

3. SEA NYMPH APPLICATION - BTS

3.1 This application is based on data from the following sources.

3.1.1 Post EDM Planning Technical Report, Data Item D002, January 1977.

3.1.2 SEA NYMPH Navy Training Plan, NTP E20-7502, August 1976.

3.2 BTS Conditions Using Cost Factor "PTP"

The cost factor "PTP" will define the number of professionally skilled civilian maintenance personnel to receive initial training. The initial maintenance training courses will be held at GTE Sylvania, Mountain View, CA. The class size will be twelve (12) students and the training course duration will be twenty-four (24) weeks.

3.2.1 Origin and Destination Concerning Government Engineers and Senior Technicians (12)

Personnel	Origin	Destination
2 - PME-107	Washington, DC	San Jose, CA
4 - NUSC, NL	Groton, CT	San Jose, CA
6 - NESEC, SD	San Diego, CA	San Jose, CA

3.2.2 Car Rental (4) - For Professionals

This analysis will be based on three (3) persons per rental vehicle.

3.3 BTS Conditions Using Cost Factor "PTM"

3.3.1 The cost factor "PTM" will define the number of O&M skilled military maintenance personnel to receive initial training. The initial maintenance training courses will be held at GTE Sylvania, Mountain View, CA. The maintenance training course duration will be 24 weeks. The operator training course will be 12 weeks.

3.3.1.1 The number of military personnel attending the maintenance courses will be a total of thirty-six (36).

3.3.1.2 The number of military personnel attending the operator courses will be a total of eighty (80).

3.3.2 Origin and Destination Concerning Military Students for Maintenance and Operator's Training Courses

3.3.2.1 Military Personnel For Maintenance Training Course (36)

It is assumed that military personnel will come from the submarine operating bases in proportion to the number of SSN 637 platforms assigned.

Personnel	Origin	Destination
3 ET-1	Norfolk, VA	San Jose, CA
4 ET-2		
2 ET-1	Charleston, SC	San Jose, CA
3 ET-2		
6 ET-1	Groton, CT	San Jose, CA
6 ET-2		
3 ET-1	Pearl Harbor	San Jose, CA
4 ET-2		
2 ET-1	San Diego, CA	San Jose, CA
3 ET-2		

Grade	Estimated Service Time
ET-1	> 6 years
ET-2	> 4 years

3.3.2.2 Car Rentals for Maintenance Courses (6)

This analysis will be based on six (6) persons per rental vehicle or 6 vehicles during the matintenance training courses.

3.3.2.3 Military for Operator's Training Courses

It is assumed that the operators will come from the SSN 637 platforms and the Navy Security Group detachments.

Personnel	Origin	Destination
4 ET-2 4 ET-3	Norfolk, VA	San Jose, CA
4 ET-2 4 ET-3	Charleston, SC	San Jose, CA
16 ET-2 16 ET-3	Groton, CT	San Jose, CA
12 ET-2 12 ET-3	Pearl Harbor	San Jose, CA
4 ET-2 4 ET-3	San Diego, CA	San Jose, CA

Grade	Estimated Service Time
ET-2	> 2 years
ET-3	> 3 years

3.3.2.4 Car Rentals (14) - For Operators

This analysis will be based on six (6) persons per rental vehicle or 14 vehicles rented during the operator courses.

3.4 SEA NYMPH PRIME Hardware Maintenance Qualifications

3.4.1 It is assumed that a military person must have at least four to six years of enlistment with the appropriate Naval technical training to be considered for SEA NYMPH PRIME hardware maintenance.

4. DATA REQUIREMENTS - BTS

4.1 The necessary data required to calculate the cost factor "BTS" using PTP and PTM are as follows:

4.1.1 Air Travel - Round Trip

Origin	Destination	Fare
Washington, DC	San Jose, CA	\$392.00
Groton, CT	San Jose, CA	\$452.00
Norfolk, VA	San Jose, CA	\$414.00
Charleston, SC	San Jose, CA	\$398.00
San Diego, CA	San Jose, CA	\$118.00
Pearl Harbor	San Jose, CA	\$280.00

#### 4.1.2 Car Rental - Hertz Corporation

The car rental is based on an economy vehicle, class C at a monthly rate of \$448.00 which is \$14.93 per day for 30 days.

#### 4.1.3 Subsistence

Subsistence for military personnel will be \$41.00 per day (per diem) and for civilian personnel will be \$41.00 maximum.

### 5. CALCULATION - BTS

#### 5.1 BTS Using PTP (Professional Maintenance)

##### 5.1.1 Air Fare - Round Trip - Civilian

From	To	Fare	Tickets	Total
Washington, DC	San Jose, CA	\$392.00	2	\$784.00
Groton, CT	San Jose, CA	\$452.00	4	\$1,808.00
San Diego, CA	San Jose, CA	\$118.00	6	<u>\$708.00</u>
Grand Total				\$3,300.00

##### 5.1.2 Car Rental - San Jose, CA (24 weeks)

Vehicle/Month	No. Months	No. Cars	
(\$448.00)	(6)	(4)	= \$10,752

##### 5.1.3 Subsistence

Personnel	Allowance	No. Days	
(12)	(41.00)	(168)	= \$82,656

##### 5.1.4 Subtotals

Air Fares:	\$3,300.00
Car Rental:	\$10,752.00
Per Diem:	<u>\$82,656.00</u>
Total (5.1)	\$96,708.00

TD 5699

5.2 BTS Using PTM (Maintenance) (36)

5.2.1 Air Fare - Round Trip - Military

From	To	Fare	Tickets	Total
Norfolk, VA	San Jose, CA	\$414.00	7	\$2,898.00
Charleston, SC	San Jose, CA	\$398.00	5	\$1,990.00
Groton, CT	San Jose, CA	\$452.00	12	\$5,424.00
Hawaii	San Jose, CA	\$280.00	7	\$1,960.00
San Diego, CA	San Jose, CA	\$118.00	5	<u>\$590.00</u>
			Grand Total	\$12,862.00

5.2.2 Car Rental - San Jose, CA (15 weeks)

Vehicle/Month	No. Months	No. Cars	
(\$448.00)	(3.75)	(6)	= \$10,080.00

5.2.3 Subsistence

Personnel	Allowance	No. Days	
(36)	(41.00)	(105)	= \$154,980.00

5.2.4 Subtotals

Air Fares:	\$12,862.00
Car Rentals:	\$10,080.00
Per Diem:	<u>\$154,980.00</u>
Total (5.2)	\$177,922.00

5.3 BTS Using PTM - Operators (80)

5.3.1 Air Fare - Round Trip - Military

From	To	Fare	Tickets	Total
Norfolk, VA	San Jose, CA	\$414.00	8	\$3,312.00
Charleston, SC	San Jose, CA	\$398.00	8	\$3,184.00
Groton, CT	San Jose, CA	\$452.00	32	\$14,464.00
Hawaii	San Jose, CA	\$280.00	24	\$6,720.00
San Diego, CA	San Jose, CA	\$118.00	5	<u>\$590.00</u>
			Grand Total	\$28,270.00

5.3.2 Car Rental - San Jose, CA (15 weeks)

Vehicle/Month	No. Months	No. Cars	
(\$448.00)	(3.75)	(14)	= \$23,520

5.3.3 Subsistence

Personnel	Allowance	No. Days	
(80)	(41.00)	(105)	= \$344,480.00

5.3.4 Subtotals

Air Fares:	\$28,270.00
Car Rentals:	\$23,520.00
Per Diem:	<u>\$344,480.00</u>

Total (5.3) \$396,270.00

## 5.4 Summary - BTS Costs

The cost factor "BTS" is calculated in this report as the mean ( $\bar{X}$ ) value for the sum of cost factors PTP and PTM.

5.4.1 BTS - Using PTP

For Professionals: \$96,708.00

5.4.2 BTS - Using PTM

For Maintenance: \$177,922.00

For Operator's: \$396,270.00

5.4.3 Mean ( $\bar{X}$ ) - BTS

For PTP + PTM

5.4.4  $\bar{X}_{BTS}$ 

$$\therefore \bar{X}_{BTS} = \frac{BTS_{PTP + PTM}}{\text{Total Students PTP + PTM}} = \frac{670,900}{128}$$

$$\bar{X}_{BTS} = \$5,241.00/\text{man}$$



Appendix B  
LCC TRADEOFF ANALYSES

Number	Topic	Inputs Required
1	What would be the cost impact if a portable screener was placed at each IMA for Sea Nymph digital circuit cards (for Sea Nymph Prime)?	<p>Number of Sea Nymph circuit cards considered to be screenable (LSA output).</p> <p>Number of good circuit cards being turned in for repair (AN/BRD-7 data from NESEC SD).</p> <p>Cost of screeners for each IMA (assume \$25K).</p> <p>Cost of shipping good circuit cards to depot (SPCC).</p> <p>Cost of screening circuit cards at depot (NESEC SD).</p> <p>Cost of circuit card interface devices (NESEC SD).</p> <p>Cost of screening programs for circuit cards.</p> <p>Cost of training for IMAs to use screener.</p>
2	What would be the cost impact of sparing each LRA on the submarine, in accordance with the modular repair concept as compared with a minimal set of resident spares for the E Suite with carry-on MCSE for deployments?	<p>Cost of set of spare LRAs (provisioning list).</p> <p>Cost of a set of resident spares (LSA output).</p> <p>Cost of a set of MCSE for E Suite (LSA output).</p> <p>Number sets of MCSE to be procured (Navy ILS Plan).</p>

Number

Topic

Inputs Required

3

What would be the cost impact if a portable screener was placed at each IMA and the IMA was allowed to make piece part repairs.

Number of Sea Nymph circuit cards considered to be screenable.

Number of GFE circuit cards (BRD-7, UYK-20) that are considered to be screenable.

Cost of screeners, training on screener use.

Cost of documentation to cover piece part repair.

Cost of circuit card interface devices.

Cost of training to use screeners (a recurring cost).

Cost of establishing tender load lists for piece parts.

Cost of depot handling and repair.

Cost of shipping circuit cards.

4

What are the long term cost impacts if the bulk of the technical manual is placed on microfilm or microfiche instead of printing it entirely on hard copy?

Cost of updating a printed page.

Cost of updating a microfilm roll.

Cost of updating microfiche cards.

Cost of reader-printer if purchased for Radio Room.

Cost of using BQQ-5 Reader Printer.

B-4	Number	Topic	Inputs Required
	5	What would be the cost impact if the IMAs/ submarines were allowed to make selected piece-part repairs to analog modules, instead of always sending them to the Depot.	List of piece parts on each analog module that could be replaced at O/I level (LSA output). Cost of transporting analog modules to Depot. Cost of handling and repairs at Depot. Cost of establishing piece parts on tender. Cost of establishing piece parts on submarine. Cost of documentation for tender repairs. Cost of documentation for submarine repairs. Cost of training of O/I levels for repairs. Cost of equipment needed to make repairs.

INITIAL DISTRIBUTION LIST

Addressee	No. of Copies
NAVELECSYSCOM (PME-10)	10