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LIFE-CYCLE COSTING OF LIFE SUPPORT EQUIPMENT

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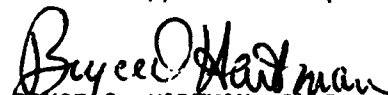
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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A feasibility study has been accomplished on applying life-cycle costing (LCC) to aircrew life support equipment (LSE). The AFLC Logistics Support Cost (LSC) model was examined and found to be too complex for application to life support devices (LSD). A potentially useful simplification of the LSC model was developed and applied to the CRU-68 oxygen regulator and the FR139 and FR140 anti-G valves, but available logistics data were insufficient for these devices. An alternate model (LCC-LSD) was developed and applied with some success. The simpler computer program requires data much more accessible from the D041.		

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20. ABSTRACT (Continued)

D039, and D062 data systems and has a plotting capability to graph LCC vs. changes in reliability or maintainability. Sensitivity analyses showed maintenance costs to be the key area where the U.S. Air Force could achieve significant savings (perhaps \$15 million).

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LIFE-CYCLE COSTING OF LIFE SUPPORT EQUIPMENT

INTRODUCTION

Objective

This report describes work performed as a continuation of an earlier research project to show the feasibility of costing the life cycle of life support equipment. The earlier research resulted in the development of an elementary model to calculate this life-cycle cost (LCC). Information from the earlier research report that is essential to understanding the new work will be included here.

The goals of this research project are to --

1. Provide a capability in the model for handling repair both at local bases and at depots.
2. Include programmed depot maintenance (PDM) in the model even when the devices are still in safe operating condition.
3. Add a feature to the model that will discount costs over the lifetime of devices.
4. Obtain data on transit, repair, and remove/install times, and enhance the capability of the model to handle the data.
5. Obtain data on the number of bases using life support equipment and apply the model to several such items, subject to the availability of data.

The achievement of these goals will enhance the methods used by the U.S. Air Force to study the LCC of life support equipment. In particular, using a computer implementation of the model will enable the Air Force to make design decisions for life support items to reduce the LCC of such equipment.

Analyzed Items

The earlier research project analyzed a Model CRU-68 oxygen regulator and anti-G valves Models FR139 and FR140. This report includes updated analyses of those items as well as analyses of the following items:

Anti-G suit, Model CSU-13/P
Oxygen mask, Model MBU-5/P
Oxygen connector, Model CRU-60/P

We were unable to acquire data on the newer oxygen regulator, Model CRU-73.

LOGISTICS-SUPPORT-COST MODEL OF AIR FORCE LOGISTICS COMMAND (AFLC)

One major objective of the earlier study on LCC was to determine the feasibility of applying the AFLC Logistics Support Cost (LSC) Model to life support equipment. If that model proved to be unfeasible, then an attempt was to be made to determine if developing a usable model was within the state-of-the-art.

The first step in this task was to thoroughly review the LSC model as presented in the user's handbook. This handbook describes such things as basic modeling techniques, details of the LSC model, and computer application of the model. Of major interest in this handbook were the ten equations that collectively make up the LSC model.

The ten equations were analyzed and evaluated for applicability to life support equipment. This analysis yielded a modified set of equations that seemed reasonably appropriate. Seven equations were eliminated from our consideration because they either required data not readily available, were relative to fixed assets such as facilities, or did not apply due to configuration (for example, engines and fuel consumption). No attempt was made to alter the current LSC approach, but merely to ascertain the feasibility of its application for life support equipment. Appendix A gives the three applicable equations from the LSC model. The feasibility of using the LSC model came down to determining the availability of the data required for these three equations. The availability and appropriateness of the data will be discussed in the "Availability of Data" section.

OTHER AIR FORCE APPLICATIONS OF LCC MODELS

The Air Force is taking an active interest in applying LCC to systems acquisition. The introduction of the new programmable calculators has provided a tool that allows LCC evaluation in design and support options. The key advantage of this tool is that it shortens the feedback loop for information on LCC impacts. An LCC model for use with the TI-59 handheld calculator has been developed. (A user's handbook is available through the Directorate of Cost Analysis, Comptroller, ASD, Wright-Patterson AFB, Ohio 45433.) This model does not include the following costs:

- Training equipment and services
- Documentation
- Facilities
- War-readiness material

Our evaluation of this model indicated that it is basically the same in theory, right down to the LCC equations, as the LSC model that we concentrated on for this study.

Two Air Force programs have recently utilized LCC. The ACES-II ejection-seat program used the AFLC LSC model for source selection. The Survival Avionics System had The Analytic Sciences Corporation develop an LCC model to evaluate the combined cost of acquiring modern systems and supporting them over their operational life.

AVAILABILITY OF DATA

A computer, no matter how sophisticated, is only as good as the data input to it. Our investigation into the LCC of life support equipment has shown that the data needed for such effort is, at best, "somewhere in the system." It was exceedingly difficult to decipher what many variables represented, what the units were, and what relationship existed between the data maintained at collection points and the variables named in the LSC model equations. An example of this in various equations is the MTBF parameter--identified as mean time between failures, in operating hours. This parameter is not applicable to all life support items because some get removed for other reasons, such as expiration of calendar months. Another example is PFFH, or peak force flying hours. It is defined as the expected fleet flying hours for 1 month during the peak usage period. This term had no apparent data source.

According to our findings, data relative to things such as mean time to failure, cost of repair, and man-hours to repair are maintained at the various Air Logistics Centers of AFLC. The San Antonio and Oklahoma City centers were visited so that relevant data could be collected.

The primary sources of data turned out to be the following computation systems: the D041 Recoverable Consumption Item Requirements, for the oxygen regulator and valve; the D039 Equipment Item Requirements, for the anti-G suit; and the D062 Economic Order Quantity Buy, for the oxygen mask and connector.

The D041 system computes replenishment spares requirements for certain items. Failure, replacement, condemnation, and other reliability rates are mechanically and manually developed on the basis of past usage and program data accumulated over a set time period. This time period may be based on flying hours, calendar months, programmed depot maintenance, or engine overhauls.

Recoverable items not routinely serviced at depot level are handled by the D039 system. Item-by-item details on this equipment are not kept at depot level, but general information regarding number in service, in inventory, and in place at each base is available at depot level. These items may be repaired or adjusted at base level, and only a local record of repairs or adjustments is kept.

The D062 system is used for unrecoverable items. These items are accounted for at the depot level to the extent of the number on hand, number on order, past demand history, and reorder level. Although the status of items at the depot is known in considerable detail, items beyond the depot are out of the accounting system. The only link between the two sets of items is the history of demands. That is, the number of items for replacement is known, but the rate of replacement is not known. D062 equipment may be repaired at base level; but if such repair is not feasible, the item is condemned at base level and not returned to the depot.

The first research project concluded that it was not feasible to use the Air Force Logistics Command LSC model to analyze the LCC of the oxygen

regulator and valve (D041 system). Because data required for the LSC model was not available in a form we could use and was not always appropriate for life support equipment, we devised a simple LCC program for direct use on the D041 data.

Early in this second research project, we had to decide whether to use the model developed for the D041 items or to pursue a different method to analyze the LCC of the new items--the anti-G suit and the oxygen mask and connector. After reviewing the available data for the new items and their maintenance strategies, we decided that this model was appropriate for the analysis and would be our life-cycle cost for life support devices (LCC-LSO) model.

Interpretation of the factor printouts proved to be time consuming and difficult. After comparing information gleaned from the printouts with comments from people involved in Air Force logistics, we concluded that the factor printouts should be used as guidelines or approximations but not as exact representations of equipment systems.

PROGRAMMED DEPOT MAINTENANCE

One effect of PDM on the LCC-LSO model is to change the demand rate; i.e., PDM-imposed overhauling of items before they fail results in smaller mean time between demands (MTBD). PDM should also result in lower repair costs because inspection of items while still in operating condition should reduce the number of potentially expensive major failures.

PDM could be included in the LCC-LSO in two ways. The first is to supply two different demand rates, one for PDM and one for item failure; then determine the cost for a PDM overhaul and the average cost of repairing a failed item. From this information, calculate the annual PDM maintenance cost and the annual failed-item maintenance cost and use these costs in an incremental LCC analysis.

The second method is to sum the PDM demand rate and the failed-item demand rate and get an average demand rate. Then calculate an average maintenance cost for the two demand types. The average demand rate is used to find the number of annual repairs. Multiplying this number by the average maintenance cost gives annual maintenance cost.

The LCC-LSO model does not include a specific PDM input or analysis. PDM is mentioned in the D041 information system instruction manual, but the D041 factor printout only gives percent of items undergoing PDM that are found to be defective. PDM is not used for the D039 or D062 items analyzed in the research.

CHANGES IN LCC-LSO COMPUTER PROGRAM

The following changes have been made in the original LCC-LSO model:

A breakdown of bases into two groups, continental United States (CONUS) and overseas, and corresponding modification in transportation time.

An added capability to provide present-worth analysis at user-specified interest and inflation rates.

A modification to allow depot and base repair capability together, as opposed to only base or only depot repair capability.

An added plotting capability, called at the user's discretion, to give graphic display of model output.

A new multiple-run capability with variable MTBD and repair time.

A change of some classifications from standard data to input data to recognize differences between items.

These changes are discussed in detail in the "Incremental LCC-LSD Model" section.

Transportation Times

Some changes have been made in the LCC-LSD model so that transportation information will more accurately model the actual supply cycle. Transportation times depend upon the priority assigned to the items to be shipped. Low priority is usually given for the items investigated in this report, so transportation time associated with low priority is used in the program. The time delay from day of base requisition to day of base receipt is 28 days, of which 13 is the time of actual travel. These times represent the maximum expected. The 28 figure is now used for "base-depot transit delay" standard data for CONUS bases only. For bases overseas (including Alaska and Hawaii), an additional 38 days is required, for a total of 66 days. The 66 figure is now used for overseas "base-depot transit delay" standard data.

Because of the substantial travel time difference between CONUS bases and those overseas, the total number of bases where an item is used must be separated into these categories. The program then takes the extra travel time into account when calculating base and depot inventory levels.

Present-Worth Analysis

The capability of present-worth analysis is included in the LCC model for use in justifying changes in initial costs. For example, present-worth analysis can show the net dollar result of increasing the manufactured first cost so that future maintenance savings can be realized. A present-worth analysis will find the present, equivalent lump-sum amount of future annual expenditures. By comparing the present worth of costs of two different designs, a clear-cut selection of the design with the lowest incremental LCC can be made.

The program also allows for an analysis with inflation included. The effect of inflation on the future purchasing power of dollars may have some bearing on how much should be spent now. Therefore, the three options available to the user are:

- A. No present-worth analysis
- B. Present-worth analysis without inflation
- C. Present-worth analysis with inflation

Option A may be sufficient for a general cost analysis of a new or existing item. Option B is probably best to use when comparing changes in existing item designs when inflation of prices is not significant. Option C is used to analyze costs in significant inflationary situations.

The logic behind finding the present worth of annual expenditures of savings is based on the fundamental formula

$$PW = A \left[\frac{(1+i)^N - 1}{i(1+i)^N} \right] \quad (1)$$

where: PW = present worth of equal yearly payment amounts
 A = yearly payment, or annuity
 N = number of years
 i = annual interest rate

For an LCC analysis, the annuity equals the annual maintenance cost which consists of the repair costs and the cost of new items due to condemnations. The annuity is calculated in the program with N equal to the analysis period of the item, but i is input by the user.

The formula for inflation-affected present worth is a derived formula based on the interactive effect of inflation and interest every year. The formulation is as follows:

$$PW = A \sum_{n=1}^N [(1+i_f)^n (1+i_r)^{-n}] \quad (2)$$

where: i_f = inflation rate
 i_r = interest rate

This finds the combined effect of each year of inflation and interest and then sums up this yearly effect over the years of analysis. The remaining steps are simply mathematical manipulations of this formula.

$$PW = A \sum_{n=1}^N \left[\frac{1+i_f}{1+i_r} \right]^n \quad (3)$$

Substituting $X = \frac{1+i_f}{1+i_r}$ in eq. (3) gives

$$PW = A \sum_{n=1}^N X^n \quad (4)$$

The solution to this series is known to be

$$X + X^2 + X^3 \dots + X^N = \frac{1-X^{N+1}}{1-X} - 1 \text{ for } X \neq 1 \quad (5)$$

which leads to

$$PW = A \left[\frac{1-X^{N+1}}{1-X} - 1 \right] \quad (6)$$

Replacing X with $\frac{1+i_f}{1+i_r}$ gives

$$PW = A \left[\frac{1 - \left(\frac{1+i_f}{1+i_r} \right)^{N+1}}{1 - \left(\frac{1+i_f}{1+i_r} \right)} - 1 \right] \quad (7)$$

Just as with present-worth analysis explained earlier, the user inputs the inflation rate, interest rate, and the number of years. The annuity is calculated in the program as total annual maintenance cost.

Eq. (3) is infeasible for $X = 1$. This condition occurs when the inflation rate equals the interest rate. However, it can be seen that equation (2) reduces to

$$PW = A \sum_{n=1}^N 1^n \quad (8)$$

$$PW = A \times [1^1 + 1^2 + 1^3 + \dots + 1^N] \quad (9)$$

$$PW = A \times N \quad (10)$$

Plot Capability

The revised LCC-LSD program has the capability to plot graphs of total cost vs. man-hours to repair at base or total cost vs. man-hours to repair at depot. Either plot may also be graphed for up to three different values of MTBD per graph.

In Appendix B, Figure B-1 is the standard output from the LCC-LSD program for the left-hand anti-G valve. The third line under the heading "Data Unique to Item" indicates that the time between demands is in hours. Whenever a plot is requested by the user, one standard output for the first combination of variables will be printed, followed by a table listing the values for the first and all other combinations of variables, as shown in Figure B-2. Figure B-3 shows a graph of the total cost in dollars vs. base man-hours (BMH) to repair for this valve. Three plots are shown, each for a different MTBD. The data necessary to obtain a plot is described in the "Data Input Format for LCC-LSD Computer Program" section, but a brief interpretation of input will be given here.

For each program execution, the user may choose to print or not print a graph. If a graph is not chosen, the user does not need to input any further graph data. If specifying that a graph be plotted, the user needs to input the number of MTBD values, up to a maximum of three.

The first MTBD value used will always be the one calculated from item input data. The user specifies the desired MTBDs as a fraction of the MTBD calculated from item input data.

The input for man-hours to repair is similar but not identical. The user may choose between base man-hours or depot man-hours and then specify how many man-hour values are to be plotted. Then the user specifies a fraction that will be used to calculate the man-hour values. For example, assume that the user specifies a base man-hour plot, five values are desired, and the fraction is .08. The five base man-hour values will be:

- (1) The input value for BMH = 4
- (2) $0.92 \times 4 = 3.68$
- (3) $0.84 \times 4 = 3.36$
- (4) $0.76 \times 4 = 3.04$
- (5) $0.68 \times 4 = 2.72$

The purpose of the graphing capability is to provide a fast visual aid to interpreting changes in incremental LCC due to various values of base repair man-hours, depot repair man-hours, and mean time between demands. The graph should not be used as a detailed illustration of incremental LCC.

Changes in Standard Data

In addition to transportation input changes mentioned earlier, other information previously assumed to be standard is now variable--requiring user input for each item. These changes occurred because of differences between so-called standard data for items investigated and in anticipation of variation in future data. Information that has been changed to be user-defined includes:

- (1) Depot repair days
- (2) Base repair days
- (3) Flight-hours per day per item
- (4) Depot procurement days (times from ordering new items from supplier to receiving items from supplier)
- (5) Lifetime of item

Including this information as input data will save the user from having to change the actual program code in the future.

For a group of similar items, the model allows for a percentage of total repairs to be completed at base and a percentage at depot. The user inputs the percent of item repairs done at base. The total demand for repairs can then be broken down into the number of items repaired at base and the number repaired at depot. The model incorporates a transit delay between base and depot to insure an inventory sufficient to meet demands at the desired confidence level.

Of all the items studied, only the D041 equipment (oxygen regulator and anti-G valves) had repairs at depot. The D041 factors printout gives the percent of items repaired at base and at depot.

Investigation of Cost Parameters

Investigation into several related cost parameters--namely, transportation, inventory, and cost of condemnation--indicated that specific costs for individual items cannot be determined in most instances or that the cost contribution is negligible. Transportation costs as a whole are grouped among many different items, making them indeterminable for specific items.

There are two types of transport costs. First are the costs associated with shipping from contractors/suppliers to the depots. Funds for this transportation come from a large general transport fund. Individual items are not accounted for; money is simply extracted from the fund as needed for shipments. However, personnel at Wright-Patterson AFB tack a general 3% increase onto the unit price of an item and call it the "standard price." This 3% surcharge is described in the D039 and D041 study guides as "first destination

transportation." Therefore, the initial transport is represented in the computation system outputs for D039 and D041 items. Whether or not the same procedure is used on D062 items is not clear.

The second type of transport costs are those associated with shipping from depot to base and vice versa. These shipping costs are not assignable to specific items and cannot be readily estimated. Shipments going to a base are accumulated for a week and usually consist of a variety of items. All modes of transportation are used; therefore, shipping rates depend on different factors at different times. Since shipments are groups of mixed items and different forms of transportation are used, creating one rate based on weight or space occupied would be very complicated and was beyond the scope of this study.

Inventory holding costs may be available at depot level, but we could find no one with such information. We doubt that this information exists at base level.

Condemnation costs, the cost of activities associated with condemning an item, are reported as negligible. According to a base equipment specialist, condemning an item consists of writing out a condemnation tag, ordering another item from the depot, and disposing of the condemned item.

INCREMENTAL LCC-LSO MODEL

Use of the Model

The incremental LCC-LSO model is used to evaluate changes in the incremental LCC of a life support item as a function of reliability, maintainability, and attendant unit cost. LCC-LSO uses data obtained from the D039, D041, and D062 data systems.

The only costs included in LCC-LSO are those that are strongly sensitive to changes in reliability, maintainability, and unit cost. They include:

- (1) Cost of the installed items
- (2) Cost of required inventories at bases and depot
- (3) Maintenance costs, including costs of replacing condemned items.

Items considered to be relatively insensitive to changed reliability and maintainability (e.g., cost of support equipment, personnel training, technical data, and facilities) are not included. We consider it better to minimize the amount of input data that must be used.

Our simplified model, nonetheless, presents some intricacies on data input. The D041 data system gives demand rates for some items, such as the anti-G valve, as the number of demands (repairs) per 100 unit flight-hours. With a demand rate of 0.5, 200 flight-hours on each of 50 units in a given month would produce $0.5(200)(50)/100 = 50$ units to be repaired in that month.

The demand rate for other items, such as the oxygen regulator, is considered more susceptible to calendar time than to flight usage. The demand rate for such items is given by the D041 data system as the number of demands per calendar month per item installed. A demand rate of 0.02 for 25,000 items installed would produce $0.02(25,000) = 500$ units to be repaired or overhauled in 1 month.

Provision is made in the LCC-LSD model for selecting the appropriate mode of expressing the demand rate for a given-type item. The D041 data system indicates the mode through the Program Selection Code (1 = per 100 flight-hours, 3 = per month). D039 and D062 items must be studied individually to determine the demand-rate mode. Usually, an equipment specialist at a depot or base can provide information as to the proper demand mode.

Model Description

Figure 1 shows the procedure used by the LCC-LSD model in determining the incremental LCC of a device. A computer program that embodies this procedure is listed in Appendix C. The essential logic of that program is shown as a flow diagram in Appendix D.

CALCULATE:

1. Mean time between demands
2. Demands per year
3. Base items: (a) Condemned
(b) Repair
(c) Base-depot repair
4. Inventory level for base
5. Depot items: (a) Condemned
(b) Repair
6. Inventory level for depot
7. Initial costs: (a) Installed
(b) Base inventory
(c) Depot inventory
8. Annual costs: (a) Base repair
(b) Depot repair
(c) Remove and replace
(d) Repair parts
(e) Condemnation replacements
9. Total incremental LCC over lifetime of system.

Figure 1. Model for formulation of incremental life-cycle cost.

Two simplifying assumptions need to be stated before describing the model. The first is that all using bases have the same number of installed items. Such a situation will probably never exist, but without this assumption the model, especially for large numbers of bases, would bog down in data acquisition and be significantly more complex. The second assumption is that as soon as a unit is condemned, a new one is ordered from the supplier. Although this rarely happens, the assumption simplifies the model without distorting the results.

An item to be analyzed falls into one of two categories with respect to demand rate: (1) flight-hour dependent; (2) calendar-month dependent. The components of Figure 1 for flight-hour-dependent items will be explained first, followed by a description for calendar-month-dependent items.

Items with Flight-Hour-Dependent Demand Rates

Calculate MTBD: Take the reciprocal of the demand rate, OIMD (given in demands per 100 flight-hours per item), and multiply by 100, as follows:

$$MTBD = 100/OIMD \quad (11)$$

Calculate Demands per Year (PP): Let

DMFH = flight-hours per day
TI = total items installed.

Then the quotient

$$pp = \frac{DMFH \times TI \times 365}{MTBD} \quad (12)$$

gives the demands per year.

Calculate Base-Condemned Items (BCOND): This value represents the average number of condemned units at a base at any time. Use the following equation to calculate BCOND:

$$BCOND = \frac{DMFH \times BSDT}{MTBD} \times \frac{TI}{M} \times CONDC \quad (13)$$

where:

M = number of bases
BSDT = time (days) from requisition by base equipment specialist to receipt of new item from depot
CONDC = condemnation rate, stated as fraction of demands

BSDT has two values--one for CONUS bases, another for overseas bases--hence two values of BCOND are calculated. Using CONDC in this equation implies that all condemnations are made at base. This simplifies the model without significantly altering the results.

Calculate Base-Depot Repair Items (BRPD): Some items have repairs performed at depot level. BRPD is the average number of items moving between a base and depot for repair at any time. The formula for finding BRPD is

$$BRPD = \frac{DMFH \times BSDT}{MTBD} \times \frac{TI}{M} \times (1-PERC) \times (1-CONDC) \quad (14)$$

where:

PERC = fraction of repairs done at base
 (1-PERC) = fraction of repairs done at depot
 (1-CONDC) = fraction of demands that are repairable

To accommodate both CONUS and overseas bases, two values of BRPD are calculated.

Calculate Base Repair Items (BRPB): This value represents the average number of items undergoing repair at a base at any time. The equation is

$$BRPB = \frac{DMFH \times BRCT}{MTBD} \times \frac{TI}{M} \times PERC \quad (15)$$

where:

BRCT = the span of time (days) from removal of an unserviceable item from an end article at base level until the item has been repaired at base level and is ready for reissue.

Calculate Inventory level for Base (STKR): Having items in base inventory to satisfy base demands is most desirable. Therefore, an inventory level sufficient to meet demands at a desired confidence coefficient must be determined.

Assuming that the time between demands has a negative exponential distribution, the Poisson distribution may be used to calculate the desired inventory level. Let X be the demand. The $P(X=x)$ for the Poisson distribution is given by:

$$P(X=x) = \frac{e^{-\mu} \mu^x}{x!} \quad (16)$$

where:

μ = the mean value of the distribution, or
 for the model, the average demand.

From eq. (16), the $P(X \leq x)$ is given by:

$$P(X \leq x) = P(X=0) + P(X=1) + \dots$$

$$\dots + P(X=(x-1)) + P(X=x)$$
(17)

Let $\alpha = \sum_{i=0}^x P(X=i)$. Then, if being 99% sure of meeting the demand from inventory is desired, x must be found such that the following is true:

$$P(X \leq x) = 0.99 = \alpha$$
(18)

$$0.99 = \frac{e^{-\mu} \mu^0}{0!} + \frac{e^{-\mu} \mu^1}{1!} + \dots$$
(19)

$$\dots + \frac{e^{-\mu} \mu^x}{x!}$$

$$= e^{-\mu} \sum_{i=0}^x \frac{\mu^i}{i!}$$
(20)

where:

$$\mu = \text{BCOND} + \text{BRPD} + \text{BRPB}.$$

STKB is given by the value of x that satisfies eq. (20). Two values of STKB must be calculated: one for CONUS bases, one for overseas bases.

Calculate Depot-Condemned Items (DCOND): DCOND is average number of items on order by depot at any time due to condemned items. (Base condemns item; depot instantly orders replacement.) It is given by:

$$DCOND + \frac{DMFH \times DPDT \times TI}{MTBD} \times CONDC \quad (21)$$

where:

DPDT = the span of time (days) from requisitioning an item from the supplier to receiving the item at depot.

Calculate Depot-Repair Items (DRPD): DRPD is the average number of items undergoing repair at depot at any time. When the depot sends an item to a base in exchange for an item needing repair, the item needing repair is sent to the depot and repaired; then this repair item is available for reissue. This span of time (days) is given by DRCT. Two values of DRCT are necessary: one for CONUS bases, one for overseas bases. The equation to calculate DRPD is:

$$DRPD = [(DMFH \times DRCTU) \times (TI \times \frac{MC}{M} \times (1-PERC) \times (1-CONDC))]/MTBD \quad (22)$$

$$+ [DMFH \times DRCTO) \times (TI \times \frac{MO}{M}) \times (1-PERC) \times (1-CONDC)]/MTBD$$

where:

DRCTU = CONUS DRCT

DRCTO = overseas DRCT

MC = number of CONUS bases

MO = number of overseas bases

In the current program the input DRCT is the CONUS value and the program adjusts for the overseas base.

Calculate Inventory Level for Depot (STKD): To calculate STKD, use eqs. (18), (19), and (20), with μ equal to

$$\mu = DCOND + DRPD \quad (23)$$

and STKD is the value of x that satisfies eqs. (18), (19), and (20).

Calculate Initial Costs Installed (CTALLD): This is the number of items installed, multiplied by UC--the unit cost of an item. This represents the cost of buying enough items to exactly fulfill all in-use requirements.

Calculate Initial Base Inventory Costs (CINIBS): This is given by

$$CINIBS = [(STKB0 \times MO) + (STKBU \times MC)] \times UC \quad (24)$$

where:

STKB0 = calculated base inventory level for an overseas base

STKBU = calculated base inventory level for a CONUS base.

CINIBS is the cost for filling the inventory at base level when initiating a new system.

Calculate Initial-Depot-Inventory Costs (CINID): CINID is the cost for filling the inventory at depot level when initiating a new system.

$$CINID = STKD \times UC \quad (25)$$

Calculate Annual Costs of Base Repair (CREPB): This value consists of two amounts. The first is the amount spent annually to repair items at bases. The second is the annual cost of condemning items, where the cost to condemn one item is assumed to be the same as the cost to repair one item at base level.

$$CREPB = [(PP \times CONDC) + (PP \times (1-CONDC) \times PERC)] \quad (26)$$

$$\times BLR \times BMH$$

where:

BLR = base labor wage rate per hour

BMH = base man-hours to repair an item.

Calculate Annual Costs of Depot Repair (CREPD): Any item not repaired at base nor condemned at base is treated as being repaired at depot.

$$CREPD = PP \times (1-CONDC) \times (1-PERC) \times DLR \times DMH \quad (27)$$

where:

DLR = depot labor wage rate per hour

DMH = depot man-hours to repair an item.

Calculate Annual Remove-and-Replace Cost (CRANDR): When an item fails, it must be removed from the host equipment and replaced with a good item. The time required for this is called "remove and replace" time. The annual cost is given by:

$$CRANDR = PP \times RMH \times BLR \quad (28)$$

where:

RMH = man-hours to remove and replace an item.

Calculate Annual Repair Parts Cost (CPARTS): CPARTS does not include replacement of condemned items. Only repair kits or parts are included.

$$CPARTS = PP \times (1-CONDC) \times (UC \times BMC/100) \quad (29)$$

where:

BMC = cost of repair parts or kits (as a percent of unit cost)

Calculate Annual Condemnation Replacement Costs (CCONDM): This is the cost of buying replacement items from suppliers:

$$CCONDM = PP \times UC \times CONDC \quad (30)$$

Calculate Total Annual Costs (CANUMA):

$$CANUMA = CCONDM + CPARTS + CRANDR + CREPD + CREPB \quad (31)$$

Calculate Total Incremental LCC over Lifetime of System:

$$CTOILC = CTALLD + CINIBS + CINID + (LFT \times CANUMA) \quad (32)$$

where:

LFT = Lifetime of item (years).

Items With Calendar-Month-Dependent Demand Rates

Many calculations performed for flight-hour-dependent items are identical to those for calendar-month items. Equations that must be changed are described below.

MTBD:

$$MTBD = 1/OIMD \quad (33)$$

where:

MTBD is in months
OIMD is in demands per calendar month per item.

PP:

$$PP = \frac{12 \times TI}{MTBD} \quad (34)$$

BCOND:

$$BCOND = \frac{BSDT}{MTBD \times 30} \times \frac{TI}{M} \times CONDC \quad (35)$$

BRPD:

$$BRPD = \frac{BSDT}{MTBD \times 30} \times \frac{TI}{M} \times (1-PERC) \times (1-CONDC) \quad (36)$$

BRPB:

$$BRPB = \frac{BRCT}{MTBD \times 30} \times \frac{TI}{M} \times PERC \quad (37)$$

DCOND:

$$DCOND = \frac{DPDT \times TI}{MTBD \times 30} \times CONDC \quad (38)$$

DRPD:

$$DRPD = [DRCTU \times TI \times \frac{MC}{M} \times (1-PERC) \times (1-CONDC)] / (MTBD \times 30) \quad (39)$$

$$+ [DRCTO \times TI \times \frac{MO}{M} \times (1-PERC) \times (1-CONDC)] / (MTBD \times 30)$$

DATA INPUT FORMAT FOR LCC-LSD COMPUTER PROGRAM

In this section the input format for data required by the LCC-LSD program to perform an incremental LCC analysis for an item is described. Examples of applying the program to the D041, D039, and D062 data bases are given in the next section, along with a table describing the location of required data in the various data-base printouts. The rest of this section will show proper placement of the data on each type of data card and how to arrange the cards in an input deck.

<u>Card Type</u>	<u>Description</u>	<u>Format</u>
1	Plotting option - NPLOT NPLOT = 0, no plot NPLOT = 1, plot results	I1
2	Title Any combination of alphanumeric characters. Column 1 <u>MUST</u> be blank.	80A1
3	No. of values of MTBD - NM Fraction of original MTBD desired - C(2),C(3) NM = 1 if only MTBD calculated in program is to be used on the plot; C(2) and C(3) are not used. Example: 1 Column No. 1 NM = 2 if MTBD calculated in program is to be used for the plot, and the fraction of MTBD given by C(2) is to be used for the plot; C(3) is not used. Example: 2.85 Column No. 1234 NM = 3 if MTBD calculated in program is to be used for the plot, and two fractions of MTBD--given by C(2) and C(3)--are to be used for the plot. Example: 3.85 .70 Column No. 123456789	I1,2F5.2

<u>Card Type</u>	<u>Description</u>	<u>Format</u>
4	Number of values of BMH or DMH desired on plot - NH Fraction of original value by which BMH or DMH decreases with each run - PNT Selection of BMH or DMH - NSEL NH < 10 PNT $\leq (1/NH)$ NSEL = 1 BMH will be varied and shown on plot NSEL = 2 DMH will be varied and shown on plot Example: 3 .10 2 Column No. 23 8 Three values of DMH will be plotted: DMH, 0.9 x DMH, 0.8 x DMH	I2,F5.2,I1
5	Type of present-worth analysis - INTANA Interest rate - INT Inflation rate - IFR INTANA = 1 No present-worth analysis; INT and IFR are not used. INTANA = 2 Present-worth analysis without inflation; IFR is not used. INTANA = 3 Present-worth analysis with inflation; INT and IFR are used. Example: 38.0 5.0 Column No. 23 9 INTANA = 3; INT = 8%; IFR = 5%	I2,2F6.2
6	Demand index - ID Total number of items installed - TI Lifetime of item - LFT Number of CONUS bases - MC Number of overseas bases - MO Percent of items repaired at base - PERCNT ID 1 = Demand is flight-hours dependent ID 2 = Demand is calendar-months dependent PERCENT ≤ 100.0 Example: 1 4364 10 13 2775. Column No. 5 1 1 2 22 0 5 0 56	5I5,F6.2

Card
Type

Description

Format

ID = 1
TI = 4364
LFT = 10
MC = 13
MO = 27
PERCNT = 75

- 7 Man-hours required to repair item at base - BMH 8F10.5
Man-hours required to repair item at depot - DMH
Man-hours required to remove and replace an item - RMH
Demand rate for item - OIMD
Unit cost for item from supplier - UC
Confidence coefficient for inventory - SIGMA
Cost of repair parts or kits, as percent of unit cost - BMC
Percent of failed devices that are unrepairable and are
condemned - COND

OIMD: Given in failures per unit time indicated by ID.

For ID = 1, demands per 100 flight-hours per item

For ID = 2, demands per calendar month per item

SIGMA < 1.00

Example:	4.	3.	1.5	.0031
Column No.	1	1	2	3
		1	1	1

Example:	316.7	.99	67.	16.5
Column No.	4	5	6	7
	1	1	1	1

BMH	= 4	UC	= \$316.70
DMH	= 3	SIGMA	= 99%
RMH	= 1.5	BMC	= 67%
OIMD	= 0.0031	COND	= 16.5%

- 8 Days to repair at base - BRCT 4F10.5
Average flight-hours per day per device - DMFH
Number of days to receive a new device from supplier
at depot - DPDT
Days to repair at depot from CONUS base - DRCT

Example:	6.	1.5	270.	12.
Column No.	1	1	2	3
		1	1	1

BRCT	= 6	DPDT	= 270
DMFH	= 1.5	DRCT	= 12

If more than one type of item is to be analyzed, type-2 through type-8 cards are presented for each additional item to be analyzed. A data deck has only one type-1 card.

If the plot option is not selected, type-3 and -4 cards may NOT be omitted. They may be blank; but if they are not, the data on these must be in the correct type-3 or type-4 format. This allows the user to run programs with or without plots without having to constantly remove or insert plot-information cards.

If a value is not specified, it will default to zero due to using FORMAT statements to input data.

APPLICATIONS OF LCC-LSD MODEL

D041 Items

The many changes made to the original LCC-LSD model prompted another cost analysis of the D041 items--the anti-G valve and the CRU-68 oxygen regulator. In addition to presenting updated input and new cost results, this section provides detailed documentation of where to locate needed input information.

The cost results from the updated information differed from those of the original, not so much due to program changes as to rather significant changes in input information. In the case of the regulator, the influential factors appear to be the cost of repair (increasing from 70% to 81% of unit cost) and a decrease in condemnation rate (from 3% to 2%). Since most regulators are repaired at the depot, the increased repair rate puts a greater demand on depot inventory. The fact that the overall cost increased \$3.2 million (7.5%) over the analysis completed a year ago indicates that a careful watch must be kept on input information.

Originally, the right-hand and left-hand anti-G valves were combined to form one set of data. The present analysis was conducted on each valve separately because of substantial differences between the two. When the individual valve cost results are combined, the net amount is \$240,000 (20%) less than the original. The great difference in MTBD was handled originally by using the higher figure to represent both right and left valves. By separating the MTBD to respective valves, a more accurate cost analysis is obtained.

Turning attention to Figure B-4 (Appendix B), the detailed costs are shown after an echo of the user input information. The list of costs on the top left-hand side is the user information in summary. The list on the top right-hand side is the standard information built into the program and not affected by user input. Notice that the breakdown of costs (bottom half of output) also includes relevant numerical information regarding size of inventories and number of maintenance actions. The initial inventory costs are separated into base and depot, and each component contributing to yearly maintenance is represented. The annual maintenance cost is multiplied by the

analysis period, and a total incremental LCC is presented. The LCC-LSD output for the left-hand anti-G valve is shown in Figure B-1; and for the right-hand valve, in Figure B-7.

Table 1 is a detailed guideline for finding the necessary information to run the LCC program for D041 devices. All readily available information is found in the D041 factors printout. The remaining information must be estimated or investigated through an equipment specialist. The phrases within quotes under "Location for D041" in Table 1 are titled sections of information within the factors printout. Figure 2 shows the exact locations of these titled sections.

Several variables deserve explanation to clarify the use of certain numbers or formulas. Information regarding identification of the item tells whether item failures are measured per calendar month or per 100 flight-hours. In the analysis of the regulator and valves, rough estimates have been used for total number of devices in service. The estimates were based on the factor printout section labeled "Total Item Past Installed Program." This section gives total number of flight-hours for all applications of the particular item. Applications are the number of final products (such as aircraft). The number of items per application and the percentage of applications using the item also are considered in the Past Installed Program. The problem is that the number of applications is not given, so basing the number of installed items on the total number of flight-hours creates a high probability of error. The precise numbers of applications apparently exist somewhere because these numbers are necessary to determine total flight-hours of all applications in the factors printout. Investigation into other data base outputs may provide the exact number.

The confidence coefficient of inventories is .99 for all items analyzed in this report. This guarantees that a space will be available in inventory (depot and base) 99% of the time a demand is received. The computer program in Appendix C provides a capability to assure a different confidence coefficient (SIGMA) whenever the average inventory level is less than 50 units. For average levels of 50 or greater, the program will assure 99% confidence regardless of the input value of SIGMA, due to the use of the normal deviate 2.33 in three formulas near statements 660, 670, and 700.

The repair cost represented in the factors printout as "Unit Repair Cost" consists of cost of repair parts and/or kits plus the labor involved. The labor portion of this cost is subtracted out so that labor cost can be identified separately. The revised repair cost is then divided by unit cost and the quotient expressed as a percentage for BMC.

Table 2 describes the input data used for the analysis of the oxygen regulator.

TABLE 1. LOCATION OF DATA ITEMS IN COMPUTATION SYSTEM PRINTOUTS

<u>Variable Description</u>	<u>Input Variable</u>	<u>Location for D041</u>	<u>Location for D039</u>	<u>Location for D062</u>
1. Identification of item-- ID = 1, flight-hours depend. ID = 2, calendar-months depend.	ID	Top row of information - "PGM SEL" First digit: if = 1, hours program if = 3, months program*(1)	Investigate, estimate	Investigate, estimate
2. Total number of items in service	T1	Investigate*(1)	From Format 50, Sec. D, under "Past Qtrs Reported In Use," find average of assets in use over most recent 4 quarters	Investigate
3. Assumed lifetime (yrs)	LFT	Investigate, estimate	Investigate, estimate*(2)	Investigate, estimate
4. Percent of repair work done at base rather than at depot	PERCNT	Under "Rates & Percents," use number for "Base Processed %"	Almost always 100%; some items may have depot repair	Always 100%; no depot repairs
5. Number of CONUS bases using item	MC	Investigate, estimate	Format 100, Sec. 1, lists all bases using item; count those in CONUS	Investigate, estimate
6. Number of overseas bases using item	MO	Investigate, estimate	Count from Format 100, Sec. 1	Investigate, estimate
7. Man-hours to repair at base	BMH	"Unit Repair Man-hours"***	If applicable, investigation needed	If applicable, investigation needed
8. Man-hours to repair at depot	DMH	"Unit Repair Man-hours"***	Most often zero; no depot repairs	Always zero
9. Man-hours to remove item and install new one	RMH	Investigate, estimate	Investigate, estimate	Investigate, estimate

10. Demand rate for item	OIMD	Under "Rates & Percents," use number for "Total OIM Demand Rate"	In Format 50, Sec. D, use condemnation factor + repair factor--both found under "Rate"; top decimal is repair; bottom is condemnation. *(2)	See text, pp. 36-38
11. Unit cost	UC	"Unit Price"	In Format 250, "Unit Cost" column, "Total w/FDT" row	"Unit Price"
12. Confidence coefficient of inventories	SIGMA	Usually use .99, otherwise whatever user desires*(1)	Usually .99 (same discussion as D041)	Usually .99 (same discussion as D041)
13. Cost of repair parts, as percentage of unit cost	BMC	Take number under "Unit Repair Cost"; subtract out labor (labor = repair man-hours x labor rate); express as % of unit cost*(1)	If applicable, investigation necessary	If applicable, investigation necessary
14. Percentage of devices condemned per year	COND	"Depot OH Condemnation %"	Investigate, estimate*(3)	Usually 100%, unless some repairs made
15. Time to repair at base	BRCT	"Repair base," top row, use number portion only	If applicable, investigation necessary	If applicable, investigation necessary
16. Flight-hours per day/device	DMFH	Investigate, estimate	Investigate, estimate	Investigate, estimate
17. Time for depot to procure a device from manufacturer	DPDT	Investigate, estimate	In format 250, column "Buy Net Requirements," row "Percent Lead/Mos."	Under "Lead Time," add "Admin" to "Prod"
18. Time to repair at depot	DRCT	"Cycle Depot," top row	Usually zero; no depot repairs	Always zero; no depot repairs
		All D041 Information in factors printout	All D039 Information in D039 output - Format 50, Format 100, Format 250	All D062 Information in EOQ Computation Notice

*See explanation in text: (1) p. 25, (2) p. 30, (3) pp. 30 and 34

**Investigation necessary to distinguish between depot and base repair hours.

LC BMC BMH, DMH FACTORS PRINTOUT BRCT DRCT ID
 DDMMYY:MM:SS INITL RUN NID JUN 80
 DIV EQPT MASTER STOCK NO MGR ITEM NAME ACTIVITY ERRC NEW ITEM CAT BASE DEPT CYCLE PGM ITEM
 SPEC DES
 V LJ 16601C1952729 NTA REGULATOR CHE 7 RE 04A 037 3X00 2AES
 UNIT PRICE UNIT REPAIR COST UNIT REPAIR MANHOURS SDR & Z SDR & Z SDR & Z
 468.70E 487.79A 6.0A
 PAGE NO...025159
 PRINT DATE...80 JUL 27
 PROGRAM BEGIN DATE...86 OCT

LAST USED	CURRENT			FORECAST			OIMD	CURRENT	FORECAST		
	12 MTHS	24 MTHS	36 MTHS	1ST	2ND	3RD			1ST	2ND	3RD
0-0150C	0-0138C	0-0144C	0-0144C	0-0144C	0-0144C	0-0144C	PDM JR CONDEMNATION %.....	DS	0	0	0
0-0150C	0-0131	0-0135	0-0135	0-0135	0-0135	0-0135	ENGINE OH JR CONDEMNATION %.....	DS	0	0	0
0-0010	0-0007	0-0009	0-0009	0-0009	0-0009	0-0009	MISTR JR CONDEMNATION %.....	DS	0	0	0
							PDM NON/JR REPLACEMENT %.....	SE	5	5	5
							ENGINE OH NCM/JR REPLACEMENT %.....	DS	0	0	0
							MISTR NON/JR REPLACEMENT %.....	DS	0	0	0
93C	95C	94C	94	94	94	94					
71	5	6	6	6	6	6					
1C	1C	1C	1	1	1	1					
2C	2C	2C	2	2	2	2					
2C							NON/JR REPAIR %..6..PDM..130	ENG OH..	0	MISTR..	5

INTERCOM STK NR	TYPE USAGE	OBS CODE	JUL 78/79	AUG 78/79	SEP 78/79	OCT 78/79	NOV 78/79	DEC 78/79	JAN 79/80	FEB 79/80	MAR 79/80	APR 79/80	MAY 79/80	JUN 79/80	TOTAL USAGE
1060000576947	BASE REP GENS	COND	0	0	0	0	0	0	1	0	0	0	0	0	2
	BASE NRTS	PERCENT	0	0	0	1	0	0	0	0	0	0	0	0	2
1060000621611	BASE REP GENS		5	5	5	5	4	3	6	4	4	3	3	3	106
	BASE NRTS		5	5	4	7	6	8	3	2	2	5	5	4	
	BASE REP GENS		0	0	0	1	0	0	1	0	0	0	0	0	2
	BASE NRTS		5	5	5	4	4	3	5	4	4	3	3	3	
1060000795246	BASE REP GENS		4	4	4	5	5	4	4	4	3	7	6	4	95
	BASE NRTS		4	4	4	3	3	2	4	4	4	3	3	2	
	BASE REP GENS		4	4	4	5	5	4	4	4	3	7	6	4	
	BASE NRTS		4	4	4	3	3	2	4	4	4	3	3	2	

Figure 2. D041 factors printout.

TABLE 2. OXYGEN REGULATOR (D041 INPUT)

<u>Variable</u>	<u>Location</u>	<u>Comment</u>
ID = 2	Fig. 2, ID	First digit of "PGM SEL" = 3, hence ID equal 2
TI = 25,000	--	Investigation done in original analysis (from 1978 data) resulted in estimate of 25,000
LFT = 10		Estimate
PERCNT = 7.	Fig. 2, PERCNT	
MC = 45	--	Estimate made on MC, MO based on 60 total bases used in original analysis
MO = 15		
BMH = 6.	Fig. 2, BMH	
DMH = 6.	Fig. 2, DMH	Investigation necessary to determine if base repair hours differ from depot repair hours
RMH = 1.5	--	Estimated
OIMD = 0.02	Fig. 2, OIMD	Rounded .015 up to .02
UC = 469.00	Fig. 2, UC	Rounded 468.7 up to 469.00
SIGMA = 0.99	--	Assumed safety margin
BMC = 81.	Fig. 2, BMC	Labor cost = $6 \times 18.05 = 108.3$; subtract from 487.79 (BMC) = 379.49
		Percentage = $\frac{379.49}{468.70} = 81\%$ of UC
COND = 2.	Fig. 2, COND	
BRCT = 4.	Fig. 2, BRCT	
DMFH = 1.5	--	Estimate, not really pertinent since device is calendar-month dependent
DPDT = 180.	--	Estimate
DRCT = 37.	Fig. 2, DRCT	

D039 Items

Our investigation of the anti-G suit indicates that D039 items can be analyzed with the LCC program for meaningful results. The negligible repair time for the anti-G suit (as for most D039 items) eliminates the need for some basic input information required for analysis of D041 items. This situation causes the presence of zeros for some input variables and output results concerned with maintenance. However, meaningful information for inventory and condemnation costs are still computed leading to a total incremental LCC. The format for input information does not change because of nonrepairable items; it will just contain some zeros. If repairable D039 items are to be analyzed, the same information is required as for D041 items.

Three basic sources of information are required to complete input for D039 items:

- (1) Format 50 -- Item Management Data
- (2) Format 100 -- Reported Assets/Requirements Details
- (3) Format 250 -- Projected Requirements/Assets Summary

Though much of the information does not appear in these format printouts, the critical data do. Our efforts to obtain the missing information in some form of data-base printout were unsuccessful. The indications are that repair data on D039 items are kept if the time and/or cost is significant. Persons more familiar with the data bases may be able to find that information.

Table 1 described how input data for D039 items in general can be obtained. Figures 3, 4, and 5 give the exact locations of printed information on example printouts. A couple of variables from Table 1 require further explanation. The assumed lifetime variable is stated in the table as requiring investigation or estimation. However, Format 50 contains a space for average life expectancy which is computed in most instances by an equipment specialist. For the D039 item analyzed in this report (the anti-G suit), the number was not entered on the printout, so we assume that this information will not be present for future analysis. If the average life expectancy has been investigated and printed, its location will be in section A, line BBBBBB, column 66-67 of Format 50.

A major difficulty arises in distinguishing an accurate demand rate (OIMD) for D039 items. A replacement factor given in Format 250 represents average number condemned (per year) divided by average number in use. In essence, it is a condemnation rate. We found, however, that the replacement factor is influenced by misleading figures because it represents all sizes or variations of the master stock number. For example, the anti-G suit supposedly has a .25 replacement factor (according to the Format 250 printout), but investigation proved that the master stock number, 8475005458197, has only a .017 condemnation rate. The factor had been inflated by interchangeable stock numbers, most of which have a condemnation rate of .999 for one reason or another. Therefore, investigation is urged in selecting an accurate demand rate; especially to guard against the inclusion of insufficient data from substitutable or interchangeable stock numbers. The condemnation rate and repair rate are used instead of the replacement factor when repairs are performed on the anti-G suit.

The condemnation percentage (COND) is determined by dividing the condemnation rate by the demand rate. For example, consider the following printout figures:

Repair rate = .05
Condemnation rate = .20

The demand rate (OIMD) equals $.05 + .20 = .25$, if no other interchangeable stock numbers are to be included. Therefore, the condemnation percentage (COND) = $.20 \div .25 = 80\%$. If the repair rate equals zero, the condemnation percentage becomes 100%.

The input data used for the analysis of the anti-G suit is shown in Table 3. Much of the input is concerned with repair data (variables BMH, DMH, RMH, BMC, BRCT, DRCT), but such data were negligible for the anti-G suit. Unfortunately, we could not obtain the number of bases using the anti-G suit because this information involves the locations of certain planes. These locations were confidential, so we made a reasonable guess for the number of CONUS and overseas bases. Usually this information can be found in D039 Format 100 printout (Fig. 4). Due to these same circumstances, "average flight-hours per day" for applications using the suit was also nondeterminable, so again an estimate was made. All other information was in the format printouts.

Figure B-10 is the LCC output for the anti-G suit. The top half of the output is the echo of input data divided between the input unique to this item (left side) and the standard input for all items (right side). In the unique input data, the number for mean flight-hours between demands is calculated directly from the demand rate. Also in the same column, the number of bases is separated between CONUS and overseas.

The bottom half of the output report (Fig. B-10) is the cost analysis in terms of number and cost. For the anti-G suit, \$3.26 million is necessary to initially supply the 60 bases with installed items. Each CONUS base requires two items in inventory for 99% security of not running out; each overseas base requires three items, with the extra item reflecting the greater time for resupply. The cost to initially stock all bases is \$19,845. For the 99% security at depot level, 145 items need to be stocked (at a cost of \$21,315).

Since no significant repairs are made on the anti-G suit, the annual maintenance cost is actually the cost associated with resupplying condemnations. With the demand rate used, 145 items will be condemned per year on the average. The cost of replacing the condemned items is \$21,315 per year; and over a 10-year period, \$213,150 (without discount or inflation). The total incremental LCC of using this item totals \$3.52 million.

TABLE 3. ANTI-G SUIT (D039) INPUT

<u>Variable</u>	<u>Location</u>	<u>Comment</u>
ID = ?	--	Calendar-month-dependent used because demand rate is in terms of months
TI = 22,207	Fig. 3, TI	Represents average in use over most recent 4 quarters
LFT = 10	--	Estimate; actually, suits have no specific lifetime
MC = 45	--	Estimate
MO = 15	--	Estimate
PERCNT = 100.	--	Investigation at base level revealed no depot repairs
BMH = 0. DMH = 0. RMH = 0.	--	Investigation at base level, all times are negligible
OIMD = .0012	Fig. 3, COND	Repair rate = .000 COND rate = .017 Demand rate = $\frac{.017 + .000}{12}$ = .0012 $\frac{\text{demands}}{\text{month}}$
UC = 147.	Fig. 5, UC	
SIGMA = .99	--	Estimated safe inventory coverage
BMC = 0.	--	Investigation showed insignificant repair costs
COND = 100.	--	Repair = .000, so demand rate is made up entirely of condemnations
BRCT = 0.	--	Investigation revealed negligible time loss if repair made
DMFH = 1.5	--	Estimate
DPDT = 300.	Fig. 5, DPDT	Time is given as 10 months on printout; multiply by 30 days/month
DRCT = 0.	--	Investigation showed no depot repairs

D062 Items

D062 items are unrecoverable. Once shipped from the depot, these items are no longer accounted for at depot level. This fact alone makes the assembling of input data for an LCC analysis difficult. However, a fairly accurate demand rate can be manually computed based on past demand from bases. This critical information, combined with good estimates for other data, can produce the desired cost analysis.

The input data required for an LCC analysis of a D062 item is the same as that for D039 and D041 items. As with D039 items, much of the input information for D062 items is not available on the standard printout. The missing data must be investigated, at the base or depot level for best information, or estimated. The standard printout for D062 items is titled "EOQ Computation Notice," in which three input variables can be found--OIMD (indirectly), DPDT, and UC. Many of the input variables concern repair, so barring the unusual occurrence of a D062 item requiring significant repair time and/or cost, these variables will reflect values for no repair.

Accountability of D062 items is minimal at depot level, so good estimates of total items in use and number of bases using the item can be difficult to get. The approach used in the analysis completed for this report was to find an accountable item whose end use is the same as the D062 item. Then we took the total in-use and base information for the accountable item and used these for the D062 item.

The D062 items analyzed in this report are an oxygen mask and oxygen connector. To obtain an estimate of the total number installed, we assumed that one mask and connector existed for every oxygen regulator, a D041 item for which an accurate estimate of number installed was available. Therefore, for in-use and base information, we matched the D062 items with the depot-accountable oxygen regulator.

Table 1 described how input data for D062 items in general may be obtained. Figure 6 gives the exact location of printed information on a sample EOQ Computation Notice.

The demand rate (OIMD) is determined by using the number from Monthly Rate-Demands (DMND) of the EOQ Computation Notice. One of the following two computation methods is used, based on whether the item is flight-hours or calendar-month dependent.

- (1) OIMD, flight-hours dependent: Take DMFH (flight-hours per day per device) x 30 (days/month) x TI (total in use). Divide this number (flight-hours/month) by 100 and take the result to divide into DMND (Monthly Rate-Demands).

Example:

DMFH	=	2 flight-hours per day per item
Days per month	=	30
TI	=	2000 total items in use
DMND	=	50
$2 \times 30 \times 2000$	=	120,000 flight-hours per month
$120,000 \div 100$	=	1200
$50 \div 1200$	=	.042 demands per 100 unit flight-hours.

- (2) OIMD, calendar-month dependent: Take DMND (Monthly Rate-Demands) and divide by TI (total in use).

Example: TI = 2000
 DMND = 50
 $50 \div 2000 = .025$ demands per month per item

The input data used for the oxygen connector is shown in Table 4. Most of the input has had to be investigated or estimated, which should be avoided if possible. A search into data bases interfacing with D062 or associated with end-of-quarter (EOQ) times may provide some additional solid information.

The cost results of the LCC analysis for the oxygen connector are printed in Figure B-11. The top half of this output gives an echo of input data except for mean flight-hours between demands. This number is calculated directly from the demand-rate (OIMD) input. It indicates a total of 1351 flight-hours between any condemnation, on the average. The bottom half of this output gives the desired output information. Notice that the total initial cost of supplying the necessary base items is \$413,250. The required base inventories, to be 99% sure of not running out, are 22 for CONUS and 44 for overseas bases. The associated combined cost for initial stocking is \$27,275. For the 99% security at depot, 10,363 items need to be kept in stock, at a cost of \$171,300.

For annual maintenance cost, the 10,128 so-called repairs are actually annual condemnations, because the input data reflected zero repairs. Therefore, with no repair costs, the only annual cost is the cost of replacing condemned items--\$167,416 per year. This number is multiplied by 10 to obtain the lifetime (10 years) maintenance costs. Finally, the 10-year maintenance cost is added to the initial costs to give total incremental LCC--\$2,285,983.

Figure B-12 contains the LCC-LSD output for the oxygen mask.

SENSITIVITY OF COST TO CHANGES IN RELIABILITY AND MAINTAINABILITY

The incremental LCC for the oxygen regulator is \$43,495,544 (Fig. B-4); for the right-hand anti-G valve, \$123,573 (Fig. B-7); and for the left-hand valve, \$907,337 (Fig. B-1).

To reduce LCC, possibly by improving maintainability (reducing hours to repair), design changes could be considered. We conducted a sensitivity analysis to determine the dollar savings resulting from various assumed reductions in demand rate and repair hours. This, of course, would indicate how much money could be afforded for the design changes.

For the oxygen regulator the demand rate was set at 100%, 66.7%, and 50% of the input value; and for the anti-G valves, at 100%, 50%, and 33.3% of the input values. Most regulator repair work is done at depot level, so the DMH was set at 100%, 92%, 84%, 76%, and 68% of the input DMH value. The anti-G valves are usually repaired at base level, so the BMH was set at 100%, 92%, 84%, 76%, and 68% of the input BMH value. Incremental LCC was determined for all 15 combinations (3 demand rates X 5 man-hour values) for each item.

TABLE 4. OXYGEN CONNECTOR (D062) INPUT

<u>Variable</u>	<u>Location</u>	<u>Comment</u>
ID = 1	--	Equipment specialist recommendation
TI = 25,000	--	Matched total in-use values with oxygen regulator
LFT = 10	--	Estimate
MC = 45	--	Matched base number with that of oxygen regulator
MO = 15	--	Same explanation as for MC
PERCNT = 100.	--	No depot repairs for D062 items
BMH = 0. DMH = 0. RMH = 0.	--	Investigation at base level; all times are negligible
OIMD = .074	Fig. 6, DMND	See text for computation formula; DMFH = 1.5, TI = 25,000, DMND (monthly demand) = 826
UC = 16.53	Fig. 6, UC	
SIGMA = .99	--	Estimated safe inventory coverage
BMC = 0.	--	Investigation showed insignificant costs
COND = 100.	--	Demand is entirely caused by condemnations; negligible repair time if any
BRCT = 0.	--	Investigation revealed negligible repair time
DMFH = 1.5	--	Estimate
DPDT = 365.	Fig. 6, DPDT	Must add "Administration" + "Production" under Lead Time section
DRCT = 0.	--	No depot repairs

Figures B-5, B-8, and B-2 (using MTBD, the reciprocal of the demand rate) show the results for the regulator and right- and left-hand valves respectively. The results are plotted in Figures B-6, B-9, and B-3. The greatest reduction in total cost results from reducing the repair hours (over the ranges explored).

Almost all reductions occur in maintenance costs, with the number of installed devices remaining constant and the inventories being decreased only slightly.

Doubling the MTBD for the oxygen regulators shows a reduction of \$16 million (36%). Tripling the MTBD for the right- and left-hand anti-G valves shows reductions of \$49,000 (39%) and \$534,000 (60%) respectively.

CONCLUSIONS

As a result of this study, we believe that the Logistic Support Cost Model of AFLC is too complex and has data requirements that are too vague for use with life support equipment. A model for costing the life cycle of life support devices (the LCC-LSD model) has been developed to use data obtained from the D041, D039, and D062 data bases to analyze changes in LCC due to changes in design and maintenance strategies. The LCC-LSD model calculates installed cost, initial inventory costs, and maintenance and replacement costs over the lifetime of the item to provide data for the analysis. An optional plot capability enables the user to rapidly assess the effect on LCC from reducing demand rates and repair times.

The ease and reliability of an analysis is related to the type of item studied. D041 items are the easiest to analyze and provide the most reliable results because of the detail provided in the D041 factor printout about an item and its repair history. D062 items are the most difficult to analyze and have the least reliable results because very little information is available on a D062 EOQ Computation Notice. A major problem is having to estimate the total numbers installed by matching a D062 item to an item that has a known number installed and the same end use. D039 items fall in the middle ground in both ease and reliability of analysis. Determining the number installed and number condemned from the Format 50 and Format 100 printouts is the major problem encountered in analyzing a D039 item.

For confirmation of the number installed or number condemned for D039 or D062 items, consulting an item manager or equipment specialist at a base or depot is very important.

The ease of estimating the number installed for a D041 item depends on the type of demand. For calendar-month-dependent items, the number installed is estimated very accurately by the monthly figure for past item-installed programs. For flight-hour-dependent items, estimating the number installed is difficult. If the number of each type of plane is known, then the number installed can be accurately estimated. Air Force personnel may be able to readily obtain this sensitive information.

We recognize that LCC is only one of a variety of considerations when establishing design specifications for life support equipment. For example, when justified by threat-to-life situations, reasonably high levels of reliability should be specified, along with a requirement that such reliability be demonstrated through tests. This adds to initial cost, but in addition to saving lives, it reduces annual maintenance costs. Items such as the oxygen regulator, with periodic overhaul required even though the item has not failed, should be reexamined. However, LCC analysis can identify areas where significant savings can be realized. Shelf-life is one area of potential savings which surfaced in our analysis. The short shelf-life for some items can possibly be corrected by using more durable materials, providing better sealing from environmental influence, and simplifying the design.

Finally, efforts to reduce LCC are often frustrated by the hard realities of meeting budgets and schedules. Managers are often reluctant to fund during a current year the extra development costs that will produce maintenance savings for other managers in future years. However, the U.S. Air Force could focus more attention on increased reliability in life support equipment and justify the added initial cost through LCC analysis. Reliability is attained during design, is strongly increased by simplicity of design and elimination of nonessential requirements, and is only specified in a meaningful manner when quantified and defined by test requirements.

RECOMMENDATION

The one outstanding problem still unsolved after this research is how to accurately determine the number of items installed for D039 (anti-G suit) and, especially, D062 (oxygen mask and connector) items. The LCC-LSD model computes many values based on total items installed; hence, the more accurate the input for number of items installed, the more accurate are the computed results. We recommend that a method be developed for finding the number of installed items. This can be done by finding the raw data base for the information sought. Throughout this research, we have found many data bases that collect a great variety of data; but for the most part these data were retained in raw form rather than in logical data bases of the kind needed for LCC analysis. The full potential of LCC analysis will be achieved only when the required data bases are formatted in accordance with the logic appropriate to LCC and become routinely available.

The theory of incremental life-cycle costing need not be restricted solely to life support equipment. The LCC-LSD model can be applied to any equipment where failure and repair activities contribute significantly to total life-cycle cost.

APPENDIX A. THREE PRIMARY EQUATIONS OF THE
AFLC LOGISTICS SUPPORT COST MODEL

C_1 = Cost of FLU Spares

$$= M \sum_{i=1}^N (STK_i)(UC_i) + \sum_{i=1}^N \frac{(PFFH)(QPA_i)(UF_i)(1-RIP_i)(NRTS_i)(DRCT)}{MTBF_i} (UC_i) \\ + \sum_{i=1}^N \frac{(TFFH)(QPA_i)(UF_i)(1-RIP_i)(COND_i)}{MTBF_i} (UC_i)$$

C_2 = On-Equipment Maintenance

$$= \sum_{i=1}^N \frac{(TFFH)(QPA_i)(UF_i)}{MTBF_i} [PAMH_i + (RIP_i)(IMH_i) + (1-RIP_i)(RMH_i)] (BLR) \\ + \frac{TFFH}{SMI} (SMH)(BLR) + \frac{(TFFH)(EPA)}{CMRI} (ERMH)(BLR)$$

C_3 = Off-Equipment Maintenance

$$= \sum_{i=1}^N \frac{(TFFH)(QPA_i)(UF_i)(1-RIP_i)}{MTBF_i} \left\{ (BCM_H_i)(BLR) \right. \\ + RTS_i [(BMH_i)(BLR + BMR) + (BMC_i)(UC_i)] \\ + NRTS_i [(DMH_i)(DLR + DMR) + (DMC_i)(UC_i)] \\ + [2(NRTS_i) + COND_i] [(PSC)(1-OS) + (PSO)(OS)] (1.35 W_i) \left. \right\} \\ + \frac{(TFFH)(EPA)(1-ERTS)}{CMRI} (EOH)(EUC)$$

APPENDIX B. LCC-LSD OUTPUTS, TABLES, AND PLOTS

Left-hand anti-G valve (D041 item)

- Figure B-1. LCC-LSD output
- Figure B-2. Output table of plot values (different BMH and MTBD)
- Figure B-3. Plot of life-cycle cost vs. BMH for three values of MTBD (Fig. B-2)--left-hand anti-G valve.

Oxygen Regulator (D041 item)

- Figure B-4. LCC-LSD output
- Figure B-5. Output table of plot values (different DMH and MTBD)
- Figure B-6. Plot of life-cycle cost vs. DMH for three values of MTBD (Fig. B-5)--oxygen regulator

Right-hand anti-G valve (D041 item)

- Figure B-7. LCC-LSD output
- Figure B-8. Output table of plot values (different BMH and MTBD)
- Figure B-9. Plot of life-cycle cost vs. BMH for three values of MTBD (Fig. B-8)--right-hand anti-G valve.

Anti-G suit (D039 item)

- Figure B-10. LCC-LSD output

Oxygen connector (D062 item)

- Figure B-11. LCC-LSD output

Oxygen mask (D062 item)

- Figure B-12. LCC-LSD output

INCREMENTAL LIFE-CYCLE COST OF ANTI-G VALVE, LEFT-HAND (JUNE 1980 DATA) WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:			
BASE LABOR HOURS TO REPAIR	4.00		
DEPOT HOURS TO REPAIR	4.00		
MEAN FLT. HRS. BETWEEN DEMANDS	207.73		
NO. OF ITEMS INSTALLED	140		
NUMBER OF BASES	CONUS -0	OVERSEAS 10	
UNIT COST IN DOLLARS		600.00	
PARTS MAINT. COST, PCT OF UNIT COST		19.00	
BASE LABOR HOURS TO RMV/REPLACE		1.50	
PERCENT OF CONDEMNATION		2.00	
PERCENT OF BASE REPAIR		74.00	
DAYS REPAIR DELAY, DEPOT		34.00	
DAYS REPAIR DELAY, BASE		3.00	
FLIGHT-HOURS/DAY/DEVICE		1.50	
DAYS PROCUREMENT DELAY, DEPOT		180.00	
ASSUMED YEARS LIFETIME		10	
COST OF INSTALLED ITEMS			\$ 84000.00
INITIAL INVENTORY COST			
EACH CONUS BASE	0 ITEMS		
EACH OVERSEAS BASE	6 ITEMS		
TOTAL INITIAL INVENTORY COST FOR ALL BASES			\$ 36000.00
DEPOT	34 ITEMS		\$ 20400.00
ANNUAL MAINTENANCE COST FOR 368 REPAIRS			
REMOVE/REPLACE LABOR		\$ 9963.60	
REPAIR LABOR		\$ 21201.15	
PARTS COST		\$ 41112.96	
CONDEMNATION COST		\$ 4416.00	
TOTAL ANNUAL MAINTENANCE COST		\$ 76693.71	
		X 10 YEARS	\$ 766937.11
TOTAL INCREMENTAL LIFE-CYCLE COST			\$ 907337.11

Figure B-1. LCC-LSD output for left-hand anti-G valve (D041 item).

TOTAL INCREMENTAL LIFE-CYCLE COST (CTOILC)
UNDER DIFFERENT BMH AND MTBD ARE:

BMH	MTBD (Flight-hours)	CTOILC
---	----	-----
4.00	207.73	888137.11
3.68	207.73	876702.67
3.36	207.73	865268.22
3.04	207.73	853833.78
2.72	207.73	842399.34
4.00	415.45	490868.56
3.68	415.45	485151.33
3.36	415.45	479434.11
3.04	415.45	473716.89
2.72	415.45	467999.67
4.00	629.48	354172.26
3.68	629.48	350412.56
3.36	629.48	346652.87
3.04	629.48	342893.17
2.72	629.48	339133.48

Figure B-2. Output table of plot values (different BMH and MTBD)
for left-hand anti-G valve.

TOTAL COST (\$)

888137.

\$ - MTBD = 207.73 flight hours

\$

\$

750886.

613635.

476384.

- MTBD = 415.45

339133.

- MTBD = 629.48

BMH(HR.)

Figure B-3. Plot of life-cycle cost vs. BMH for three values of MTBD (Fig. B-2)--left-hand anti-G valve

INCREMENTAL LIFE-CYCLE COST OF OXYGEN REGULATOR (JUNE 1980 DATA) WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:		CONDITIONS:	
BASE LABOR HOURS TO REPAIR	6.00	REMOVAL IS CALENDAR-MONTHS DEPENDENT.	
DEPOT HOURS TO REPAIR	6.00		
MEAN MONTHS BETWEEN DEMANDS	50.00		
NO. OF ITEMS INSTALLED	25000	STANDARD DATA:	
NUMBER OF BASES	56		
UNIT COST IN DOLLARS	14		
PARTS MAINT. COST, PCT OF UNIT COST	469.00		
BASE LABOR HOURS TO RMV/REPLACE	81.00		
PERCENT OF CONDEMNATION	1.50		
PERCENT OF BASE REPAIR	2.00		
DAYS REPAIR DELAY, DEPOT	7.00		
DAYS REPAIR DELAY, BASE	37.00		
FLIGHT-HOURS/DAY/DEVICE	4.00		
DAYS PROCUREMENT DELAY, DEPOT	1.50		
ASSUMED YEARS LIFETIME	180.00		
	10		
COST OF INSTALLED ITEMS		\$ 11725000.00	

INITIAL INVENTORY COST	
EACH CONUS BASE	13 ITEMS
EACH OVERSEAS BASE	24 ITEMS
TOTAL INITIAL INVENTORY COST FOR ALL BASES	
DEPOT	800 ITEMS
	\$ 499016.00
	\$ 375200.00

ANNUAL MAINTENANCE COST FOR 6000 REPAIRS	
REMOVE/REPLACE LABOR	\$ 162450.00
REPAIR LABOR	\$ 637149.60
PARTS COST	\$ 2233753.20
CONDEMNATION COST	\$ 56280.00
TOTAL ANNUAL MAINTENANCE COST	
	\$ 3089632.80
TOTAL INCREMENTAL LIFE-CYCLE COST	
	\$ 30896328.0
	\$ 43495544.0

Figure B-4. LCC-LSN output of oxygen regulator (n041 item).

DMH ---	MTBD (Months) ----	CTOILC -----
6.00	50.00	43495544.00
5.52	50.00	43012092.80
5.04	50.00	42528641.60
4.56	50.00	42045190.40
4.08	50.00	41561739.20
6.00	74.96	32968345.78
5.52	74.96	32645883.83
5.04	74.96	32323421.88
4.56	74.96	32000959.92
4.08	74.96	31678497.97
6.00	100.00	27668897.00
5.52	100.00	27427171.40
5.04	100.00	27185445.80
4.56	100.00	26943720.20
4.08	100.00	26701994.60

Figure B-5. Output table of plot values (different DMH and MTBD) for oxygen regulator.

43495544.
39297157.
35098769.
30900382.
26701995.

6.00

Figure B-6. Plot of life-cycle cost vs. DMH for three values of MTBD (Fig. 8-5)--oxygen regulator.

INCREMENTAL LIFE-CYCLE COST OF ANTI-G VALVE, RIGHT-HAND (JUNE 1980 DATA) WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:		CONDITIONS:	
BASE LABOR HOURS TO REPAIR	4.00	REMOVAL IS FLIGHT-HOURS DEPENDENT.	
DEPOT HOURS TO REPAIR	4.00		
MEAN FLT. HRS. BETWEEN DEMANDS	2012.07	STANDARD DATA:	
NO. OF ITEMS INSTALLED	140		
NUMBER OF BASES CONUS	3	BASE HOURLY LABOR RATE	
OVERSEAS	2	DEPOT HOURLY LABOR RATE	
UNIT COST IN DOLLARS	360.50	DAYS TRANSIT DELAY, BASE-DEPOT	
PARTS MAINT. COST, PCT OF UNIT COST	26.00	CONUS	
BASE LABOR HOURS TO RMV/REPLACE	1.50	OVERSEAS	
PERCENT OF CONDEMNATION	0		
PERCENT OF BASE REPAIR	74.00		
DAYS REPAIR DELAY, DEPOT	37.00		
DAYS REPAIR DELAY, BASE	4.00		
FLIGHT-HOURS/DAY/DEVICE	1.50		
DAYS PROCUREMENT DELAY, DEPOT	180.00		
ASSUMED YEARS LIFETIME	10		
COST OF INSTALLED ITEMS		\$ 50470.00	
INITIAL INVENTORY COST			
EACH CONUS BASE	2 ITEMS		
EACH OVERSEAS BASE	2 ITEMS		
TOTAL INITIAL INVENTORY COST FOR ALL BASES		\$ 3605.00	
DEPOT		\$ 1802.50	
ANNUAL MAINTENANCE COST FOR 38 REPAIRS			
REMOVE/REPLACE LABOR	\$ 1028.85		
REPAIR LABOR	\$ 2178.95		
PARTS COST	\$ 3561.74		
CONDEMNATION COST	\$ 0		
TOTAL ANNUAL MAINTENANCE COST		\$ 6769.54	
		X 10 YEARS	
		\$ 67695.40	
		TOTAL INCREMENTAL LIFE-CYCLE COST	
		\$ 123572.90	

Figure B-7. LCC-LSD output for right-hand anti-G valve (D041 item).

BMH ---	MTBD (Flight-hours) ----	CTOILC -----
4.00	2012.07	123572.90
3.68	2012.07	122400.41
3.36	2012.07	121227.92
3.04	2012.07	120055.43
2.72	2012.07	118882.94
4.00	4024.14	87922.70
3.68	4024.14	87336.46
3.36	4024.14	86750.21
3.04	4024.14	86163.96
2.72	4024.14	85577.72
4.00	6042.26	74731.50
3.68	6042.26	74361.24
3.36	6042.26	73990.98
3.04	6042.26	73620.71
2.72	6042.26	73250.45

Figure B-8. Output table of plot values (different BMH and MTBD) for right-hand anti-G valve.

INCREMENTAL LIFE-CYCLE COST OF ANTI-G SUIT WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:		CONDITIONS:	
BASE LABOR HOURS TO REPAIR	0	REMOVAL IS FLIGHT-HOURS DEPENDENT.	
DEPOT HOURS TO REPAIR	0		
MEAN FLT-HRS. BETWEEN DEMANDS	83333.33		
NO. OF ITEMS INSTALLED	22207	STANDARD DATA:	
NUMBER OF BASES CONUS	45	BASE HOURLY LABOR RATE	\$13.0
UNIT COST IN DOLLARS	15	DEPOT HOURLY LABOR RATE	\$18.0
PARTS MAINT. COST, PCT OF UNIT COST	147.00	DAYS TRANSIT DELAY, BASE-DEPOT	\$28.0
BASE LABOR HOURS TO RMV/REPLACE	0	CONUS	\$66.0
PERCENT OF CONDEMNATION	100.00	OVERSEAS	
PERCENT OF BASE REPAIR	100.00		
DAYS REPAIR DELAY, DEPOT	0		
DAYS REPAIR DELAY, BASE	0		
FLIGHT-HOURS/DAY/DEVICE	1.50		
DAYS PROCUREMENT DELAY, DEPOT	300.00		
ASSUMED YEARS LIFETIME	10		
COST OF INSTALLED ITEMS			\$ 3264429.0
INITIAL INVENTORY COST			
EACH CONUS BASE	2 ITEMS		
EACH OVERSEAS BASE	3 ITEMS		
TOTAL INITIAL INVENTORY COST FOR ALL BASES			\$ 19845.0
DEPOT	145 ITEMS		\$ 21315.0
ANNUAL MAINTENANCE COST FOR 145 REPAIRS			
REMOVE/REPLACE LABOR	\$ 0		
REPAIR LABOR	\$ 0		
PARTS COST	\$ 0		
CONDEMNATION COST	\$ 21315.00		
TOTAL ANNUAL MAINTENANCE COST		X 10 YEARS	\$ 213150.0
TOTAL INCREMENTAL LIFE-CYCLE COST			\$ 3518739.0

Figure 8-10. LCC-LSD output of anti-G suit (D039 item).

INCREMENTAL LIFE-CYCLE COST OF OXYGEN CONNECTOR WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:				
BASE LABOR HOURS TO REPAIR	0			
DEPOT HOURS TO REPAIR	0			
MEAN FLT. HRS. BETWEEN DEMANDS	1351.35			
NO. OF ITEMS INSTALLED	25000			
NUMBER OF BASES	CONUS 45	OVERSEAS 15		
UNIT COST IN DOLLARS		16.53		
PARTS MAINT. COST, PCT OF UNIT COST	0			
BASE LABOR HOURS TO RMV/REPLACE	0			
PERCENT OF CONDEMNATION	100.00			
PERCENT OF BASE REPAIR	100.00			
DAYS REPAIR DELAY, DEPOT	0			
DAYS REPAIR DELAY, BASE	0			
FLIGHT-HOURS/DAY/ITEM	1.50			
DAYS PROCUREMENT DELAY, DEPOT	365.00			
ASSUMED YEARS LIFETIME	10			
COST OF INSTALLED ITEMS				\$ 413250.00

INITIAL INVENTORY COST				
EACH CONUS BASE	22 ITEMS			
EACH OVERSEAS BASE	44 ITEMS			
TOTAL INITIAL INVENTORY COST FOR ALL BASES				\$ 27274.50
DEPOT	10363 ITEMS			\$ 171300.39

ANNUAL MAINTENANCE COST FOR 10128 REPAIRS				
REMOVE/REPLACE LABOR	\$	0		
REPAIR LABOR	\$	0		
PARTS COST	\$	0		
CONDEMNATION COST	\$	167415.84		
TOTAL ANNUAL MAINTENANCE COST	\$	167415.84	X 10 YEARS	\$ 1674158.40
TOTAL INCREMENTAL LIFE-CYCLE COST				\$ 2285983.29

Figure B-11. LCC-LSD output for oxygen connector (D062 item).

INCREMENTAL LIFE-CYCLE COST OF OXYGEN MASK WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:		CONDITIONS:	
BASE LABOR HOURS TO REPAIR	0	REMOVAL IS FLIGHT-HOURS DEPENDENT.	
DEPOT HOURS TO REPAIR	0		
MEAN FLT. HRS. BETWEEN DEMANDS	5882.35		
NO. OF ITEMS INSTALLED	25000	STANDARD DATA:	
NUMBER OF BASES	50	OVERSEAS	20
UNIT COST IN DOLLARS	31.69	BASE HOURLY LABOR RATE	\$13.03
PARTS MAINT. COST, PCT OF UNIT COST	0	DEPOT HOURLY LABOR RATE	\$18.05
BASE LABOR HOURS TO RMV/REPLACE	0	DAYS TRANSIT DELAY, BASE-DEPOT	
PERCENT OF CONDEMNATION	100.00	CONUS	\$28.00
PERCENT OF BASE REPAIR	100.00	OVERSEAS	\$66.00
DAYS REPAIR DELAY, DEPOT	0		
DAYS REPAIR DELAY, BASE	0		
FLIGHT-HOURS/DAY/ITEM	1.50		
DAYS PROCUREMENT DELAY, DEPOT	296.00		
ASSUMED YEARS LIFETIME	10		
COST OF INSTALLED ITEMS			\$ 792250.00
INITIAL INVENTORY COST			
EACH CONUS BASE	7 ITEMS		
EACH OVERSEAS BASE	12 ITEMS		
TOTAL INITIAL INVENTORY COST FOR ALL BASES			\$ 18697.10
DEPOT	1988 ITEMS		\$ 62999.72
ANNUAL MAINTENANCE COST FOR 2326 REPAIRS			
REMOVE/REPLACE LABOR	\$ 0		
REPAIR LABOR	\$ 0		
PARTS COST	\$ 0		
CONDEMNATION COST	\$ 73710.94		
TOTAL ANNUAL MAINTENANCE COST		\$ 73710.94	X 10 YEARS
TOTAL INCREMENTAL LIFE-CYCLE COST			\$ 737109.40

			\$ 1611056.22

Figure B-12. LCC-LSD output for oxygen mask (D062 item).

APPENDIX C

LCC-LSD COMPUTER PROGRAM LISTING


```

C(1)=1.0
NINPU=0
C
50 READ(NCRDR,26,END=1400)(NAME(I),I=1,80)
CALL TITLE
C
NINPU=NINPU+1
READ(NCRDR,4)NM,(C(JJ),JJ=2,NM)
READ(NCRDR,27)NH,PNT,NSEL
C
IF(NPLOT.EQ.1) GO TO 100
NM=1
NH=1
C
100 READ(NCRDR,32)INTANA,INT,IFR
IF(INTANA.EQ.1)GO TO 150
IF(INTANA.EQ.2)GO TO 200
WRITE(NPRT,33)INT,IFR
GO TO 250
150 WRITE(NPRT,34)
GO TO 250
200 WRITE(NPRT,35)INT
C
250 READ(NCRDR,1)ID,TI,LFT,MC,MO,PERCENT
READ(NCRDR,2)BMH,DMH,RMH,OIMD,UC,SIGMA,BMC,COND
READ(NCRDR,2)BRCT,DMFH,DPT,DRC
C
NN=0
DO 1200 K=1,NM
DO 1150 J=1,NH
NM=NM+1
IF(NN.EQ.1) WRITE(NPRT,5)
C
JJ=NH+1-J
IF(NSEL.EQ.2) GO TO 300
X(JJ)=BMH*(1.0-PNT*(J-1))
GO TO 350
300 X(JJ)=DMH*(1.0-PNT*(J-1))
350 IF(NN.EQ.1)WRITE(NPRT,6)BMH,DMH
C
C***CALCULATE MTBD, FLIGHT HOUR DEPENDENT
C
IF(ID.EQ.2) GO TO 400
MTBD=100.0/OIMD
IC(K)=MTBD/C(K)
PP=DMFH*TI*365.00/IC(K)
IF(NN.EQ.1) WRITE(NPRT,8)IC(K)
GO TO 450

```

```

C*****CALCULATE MTBD, CALENDAR MONTH DEPENDENT
C
C 400 MTBD=1.0/OIMD
      IC(K)=MTBD/C(K)
      PP=12.0*TI/IC(K)
      IF(NN.EQ.1) WRITE(NPRINT,9)IC(K)
C
C***** ECHO OF INPUT DATA
C
C 450 IF(NN.GT.1) GO TO 500
      WRITE(NPRINT,10)TI
      WRITE(NPRINT,11)MC,MD
      WRITE(NPRINT,12)UC
      WRITE(NPRINT,13)BMC
      WRITE(NPRINT,14)RMH
      WRITE(NPRINT,15)COND,BSDT
      WRITE(NPRINT,16)PERCENT,OBSDT
      WRITE(NPRINT,17)DRCT
      WRITE(NPRINT,18)BRCT
      WRITE(NPRINT,19)DMFH
      WRITE(NPRINT,20)DPDT,LFT
C
C***** CALCULATE DECIMAL EQUIVALENTS OF INPUT PERCENTS
C
C 500 BMCC=BMC/100.0
      CONDC=COND/100.0
      PERC=PERCENT/100.0
C
C***** CALCULATE FRACTION OF U.S. AND OVERSEAS BASES
C
C      M=MC+MD
      POSB=FLOAT(MD)/FLOAT(M)
C
C***** CALCULATE INTERNAL VARIABLE FOR (TI/M)
C
C      TIB=TI/M
C
C***** DETERMINE DEMAND TYPE, IC( ) IS MTBD
C
C      GO TO (550,600),ID
C
C*****DEVICE REMOVAL IS FLIGHT HOURS DEPENDENT.
C
C 550 BCONDU=DMFH*BSDT*TIB*CONDC/IC(K)
      BRPNUJ=DMFH*BSDT*TIB*(1.0-PERC)*(1.0-CONDC)/IC(K)
C
C

```

```

BCONDO=DMFH*OBSDT*TIB*CONDC/IC(K)
BRPDO=DMFH*OBSDT*TIB*(1.0-PERC)*(1.0-CONDC)/IC(K)
BRPB=DMFH*BRCT*TIB*PERC/IC(K)
DCOND=DMFH*DPDT*TI*CONDC/IC(K)
DRPD=DMFH*(DRCT+POSB*38.0)*TI*(1.0-PERC)*(1.0-CONDC)/IC(K)
GO TO 650
C*****DEVICE REMOVAL IS CALENDAR MONTHS DEPENDENT.
600 BCONDU=BSDT*TIB*CONDC/(30.0*IC(K))
BRPDU=BSDT*TIB*(1.0-PERC)*(1.0-CONDC)/(30.0*IC(K))
BCONDO=OBSDT*TIB*CONDC/(30.0*IC(K))
BRPDO=OBSDT*TIB*(1.0-PERC)*(1.0-CONDC)/(30.0*IC(K))
BRPB=BRCT*TIB*PERC/(IC(K)*30.0)
DCOND=DPDT*TI*CONDC/(IC(K)*30.0)
DRPD=(DRCT+POSB*38.0)*TI*(1.0-PERC)*(1.0-CONDC)/(IC(K)*30.0)
C***** SUM AVERAGE UNITS NEEDED IN U.S. BASE INVENTORY
650 LAMDBU = BCONDU + BRPDU + BRPB
C***** SUM AVERAGE UNITS NEEDED IN OVERSEAS BASE INVENTORY
LAMDBO = BCONDO + BRPDO + BRPB
C***** SUM AVERAGE UNITS NEEDED IN DEPOT INVENTORY
LAMDAD = DCOND + DRPD

```

```

C*****NUMBER OF INITIAL INVENTORIES NEEDED PER BASE AND DEPOT.
C
  IF(LAMDBU.LT.50.0)GO TO 660
    SIGBU=SQRT(LAMDBU)
    STKBU=LAMDBU+2.33*SIGBU
    GO TO 665
  660 STKBU=NPSSN(LAMDBU,SIGMA,II)
C
  665 IF(LAMDBO.LT.50.0)GO TO 670
    SIGBO=SQRT(LAMDBO)
    STKBO=LAMDBO+2.33*SIGBO
    GO TO 675
  670 STKBO=NPSSN(LAMDBO,SIGMA,II)
C
  675 IF(LAMDAD.LT.50.0)GO TO 700
    SIGMAD=SQRT(LAMDAD)
    STKD=LAMDAD+2.33*SIGMAD
    GO TO 750
  700 STKD=NPSSN(LAMDAD,SIGMA,II)
C
C*****COST OF INSTALLED DEVICES.
C
  750 CTALLD=TI*UC
C
C*****COST OF INITIAL INVENTORIES FOR ALL BASES.
C
  CINIBS=((STKBU*MC)+(STKBO*MO))*UC
C
C*****COST OF INITIAL INVENTORIES AT DEPOT.
C
  CINIDP=STKD*UC
C
C*****COST OF MAINTENANCE.
C
  FREOCY=IFIX(PP)
C
C***** INTERNAL PLOT CALCULATIONS AND BASE AND
C***** DEPOT LABOR COST CALCULATIONS.
C
  IF(NSEL.EQ.2)GO TO 800
    CREPAR=FREOCY*((BLR*X(JJ))*(CONDC*(1-CONDC)*(PERC)))+(DLR*DMH
    I*(1.0-PERC)))
    GO TO 850
  800 CREPAR=FREOCY*((DLR*X(JJ))*(1.0-PERC))+(BLR*BMMH*PERC))
C
C***** CALCULATE REMOVE AND REPLACE COST
C
  850 CRANDP=FREOCY*RMH*DLR

```

```

C***** CALCULATE COST OF REPAIR KITS OR PARTS
C
C      CPARTS=FREQCY*BMCC*UC*(1.0-CONDC)
C***** CALCULATE COST OF NEW REPLACEMENT EQUIPMENT
C
C      CCONDM=FREQCY*CONDC*UC
C***** SUM COMPONENTS OF ANNUAL MAINTENANCE COST
C
C      CANUMA=CRANDR*CREPAR+CCONDM+CPARTS
C*****CHECK FOR PRESENT NORTH ANALYSIS
C
C      IF(INTANA.EQ.1)GO TO 900
C      CALL INTRST
C      GO TO 950
C      900 CTOMAN=CANUMA*LFT
C*****CALCULATE THE TOTAL INCREMENTAL LIFE CYCLE COST.
C
C      950 CTOILC=CTALLD+CINIBS+CINIDP+CTOMAN
C*****OUTPUT DATA
C
C      IF(MC.EQ.0) STKBV = 0
C      IF(MO.EQ.0) STKB0 = 0
C      IF(NN.GT.1) GO TO 1100
C      WRITE(NPRNT,21)CTALLD,STKBV,STKB0,CINIBS,STKD,CINIDP,FREQCY
C      WRITE(NPRNT,22)CRANDR,CREPAR,CPARTS,CCONDM
C      IF(INTANA.EQ.1) GO TO 1000
C      WRITE(NPRNT,23)CANUMA,CTOMAN
C      GO TO 1050
C      1000 WRITE(NPRNT,24)CANUMA,LFT,CTOMAN
C      1050 WRITE(NPRNT,25)CTOILC
C
C      1100 Y(NN)=CTOILC
C      1150 CONTINUE
C      1200 CONTINUE
C***** CHECK FOR PLOT
C
C      IF(NPLOT.EQ.0) GO TO 50
C
C      IF(NSEL.EQ.2) GO TO 1250
C      WRITE(NPRNT,28)
C      GO TO 1300
C      1250 WRITE(NPRNT,29)

```

```

C 1300 NN=0
DO 1350 K=1,NM
DO 1350 J=1,NH
NN=NN+1
JJ=NH+1-J
WRITE(NPRINT,31)X(JJ),IC(K),Y(NN)
1350 CONTINUE
C
CALL PLOT(NM,NH,NN)
GO TO 50
1 FORMAT(5I5,F6.2)
2 FORMAT(8F10.5)
3 FORMAT(11)
4 FORMAT(11,2F5.2)
5 FORMAT(//11X,DATA UNIQUE TO DEVICE :*,T77,CONDITIONS :*)
6 FORMAT(14X,BASE LABOR HOURS TO REPAIR*,T54,F6.2,/,14X,DEPOT HOUR
15 TO REPAIR*,T54,F6.2)
8 FORMAT(14X,MEAN FLT. HRS. BETWEEN DEMANDS*,T48,F12.2,T80,
** REMOVAL IS FLIGHT HOURS DEPENDENT.*)
9 FORMAT(14X,MEAN MONTHS BETWEEN DEMANDS*,T48,F12.2,T80,
** REMOVAL IS CALENDAR MONTHS DEPENDENT.*)
10 FORMAT(14X,NO. OF DEVICES INSTALLED*,T52,I5,T77,STANDARD DATA:*)
11 FORMAT(14X,NUMBER OF BASES*,T33,CONUS*,2X,I3,5X,OVERSEAS*,I3)
12 FORMAT(14X,UNIT COST IN DOLLARS*,T53,F7.2,T80,BASE HOURLY LABOR
RATE*,T117,/$13.03*)
13 FORMAT(14X,PARTS MAINT. COST, PCT OF UNIT COST*,T55,F5.2,T80,DEP
OT HOURLY LABOR RATE*,T117,/$18.05*)
14 FORMAT(14X,BASE LABOR HOURS TO RMU/REPLACE*,T54,F6.2,T80,DAYS TR
ANSIT DELAY, BASE-DEPOT*)
15 FORMAT(14X,PERCENT OF CONDEMNATION*,T54,F6.2,T90,
**CONTINENTAL U.S.*,T117,F6.2)
16 FORMAT(14X,PERCENT OF BASE REPAIR*,T54,F6.2,T90,OVERSEAS*,
**T117,F6.2)
17 FORMAT(14X,DAYS REPAIR DELAY, DEPOT*,T54,F6.2)
18 FORMAT(14X,DAYS REPAIR DELAY, BASE*,T54,F6.2)
19 FORMAT(14X,FLIGHT HOURS/DAY/DEVICE*,T54,F6.2)
20 FORMAT(14X,DAYS PROCUREMENT DELAY, DEPOT*,T54,F6.2,
1/,14X,ASSUMED YEARS LIFETIME*,T54,I6)
21 FORMAT(//11X,T31,COST OF INSTALLED DEVICES*,T109,/$*,F13.2//T3
1,INITIAL INVENTORY COST*/T39,/*EACH U.S. BASE *,I0X,I6,
** DEVICES*,/,T39,/*EACH OVERSEAS BASE *,6X,I6,DEVICES*,
**/,T36,TOTAL INITIAL INVENTORY COST FOR ALL BASES*,T109,
**$,F13.2,
**/,T39,DEPOT*,T49,I6,DEVICES *,T109,/$*,F13.2//T31
*,ANNUAL MAINTENANCE COST FOR*,I6,REPAIRS*/

```

```

22  FORMAT(T39,REMOUE/REPLACE LABOR,T69,,$$,F13.2/T39,REPAIR LABOR,
    *,T69,,$$,F13.2/T39,PARTS COST,T69,,$$,F13.2/T39,CONDEMNATION CO
    *ST,T69,,$$,F13.2/T69,14(1H-)/)
23  FORMAT(T35,TOTAL ANNUAL MAINTENANCE COST,T69,,$$,F13.2,
    *//,T35,LIFETIME MAINTENANCE COST USING PRESENT WORTH ANALYSIS,
    *T109,,$$,F13.2,/)
24  FORMAT(T35,TOTAL ANNUAL MAINTENANCE COST,T69,,$$,F13.2,
    *T92,,$$,13, YEARS,T109,,$$,F13.2/T109,14(1H-)/)
25  FORMAT(T74,TOTAL INCREMENTAL LIFE CYCLE COST,T109,
    *,$$,F13.2)
26  FORMAT(80A1)
27  FORMAT(I2,F5.2,11)
28  FORMAT(1H1,49X,TOTAL INCREMENTAL LIFE CYCLE COST,50X,UNDER DIF
    $FERENT BMH AND MTBD ARE:50X,BMH,10X,MTBD,11X,CTOILC,/,
    $,50X,-----,10X,-----,11X,-----)
29  FORMAT(1H1,49X,TOTAL INCREMENTAL LIFE CYCLE COST,50X,UNDER DIF
    $FERENT DMH AND MTBD ARE:50X,DMH,10X,MTBD,13X,CTOILC,/,
    $50X,-----,10X,-----,11X,-----)
31  FORMAT(49X,F5.2,3X,F12.2,5X,F13.2)
32  FORMAT(I2,F6.2)
33  FORMAT(16X,WITH PRESENT WORTH AND INFLATION ANALYSIS,INTEREST RA
    *TE ,
    *F6.2,PERCENT, INFLATION RATE ,F6.2,PERCENT)
34  FORMAT(51X,WITHOUT PRESENT WORTH ANALYSIS)
35  FORMAT(37X,WITH PRESENT WORTH ANALYSIS, INTEREST RATE ,F6.2,PE
    *RCENT)

```

C 1400 STOP
END

```

C      FUNCTION NPSSN(AUG,ALPHA,NDEVIC)
C***** FUNCTION NPSSN USES THE POISSON DISTRIBUTION TO
C***** CALCULATE AN INVENTORY LEVEL SATISFYING USER'S
C***** DESIRED CONFIDENCE FOR MEETING DEMAND
C
C      DIMENSION P(800)
C
C      I=1
C      P(1)=EXP(-AUG)
C      SUM=P(1)
C      IF(SUM.GE.ALPHA) GO TO 200
C      DO 100 I=2,NDEVIC
C          P(I)=P(I-1)*AUG/FLOAT(I-1)
C          SUM=SUM+P(I)
C          IF(SUM.GE.ALPHA) GO TO 200
C      100 CONTINUE
C      NPSSN=I-1
C      RETURN
C      END

```

```

SUBROUTINE TITLE
COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
INTEGER BLANK,INAME(130)
DATA BLANK/'#'/
C
I=1
NPRNT=6
WHILE(NAME(I).NE.BLANK.OR.NAME(I+1).NE.BLANK) DO
  I=I+1
ENDWHILE
C
I=I-1
NK=(133-I)/2
DO 100 II=1,120
  INAME(II)=BLANK
100 CONTINUE
C
DO 200 II=NK+1,NK+I
  INAME(II)=NAME(II-NK)
200 CONTINUE
C
WRITE(NPRNT,20)
WRITE(NPRNT,30)(INAME(II),II=1,120)
C
20 FORMAT(1H1,TS4,INCREMENTAL LIFE CYCLE COST//T66,2HOF/)
30 FORMAT(120A1/)
C
RETURN
END

```

```

SUBROUTINE INTRST
COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
COMMON/UCOM2/LFT,CTOMAN,CANUMA
REAL IFR,INT
IFR=IFR/100.
INT=INT/100.

C*****PRESENT WORTH ANALYSIS WITH INFLATION
C
C      IF (INTANA.EQ.2)GO TO 100
C*****CHECK FOR INTEREST RATE EQUAL INFLATION RATE
C
C      IF (INT.EQ. IFR)GO TO 50
C-----IS FLOATING POINT EQUALITY EXPECTED
      QUO=(1+IFR)/(1+INT)
      IEXP=LFT+1
      FNUM=1-(QUO**IEXP)
      FDEN=1-QUO
      FAC=FNUM/FDEN-1
      CTOMAN=CANUMA*FAC
      RETURN
C*****INTEREST RATE EQUAL TO INFLATION RATE
C
C      50 CTOMAN= CANUMA * LFT
      RETURN
C*****PRESENT WORTH ANALYSIS WITHOUT INFLATION
C
C      100 FNUM=((1+INT)**LFT)-1
      FDEN=INT*((1+INT)**LFT)
      FAC=FNUM/FDEN
      CTOMAN=CANUMA*FAC
      RETURN
      END

```

```

SUBROUTINE PLOT(IL,IU,N)
  DIMENSION IA(3),IP(91)
  COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
  COMMON/UCOM3/ID,NSEL,X(10),Y(10),Y(30),NPRNT,IC,NINPU
  REAL IC(3),IFR,INT
  DATA IB,IA/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91/
  C
  SCALE=(Y(1)-Y(N))/40.0
  IF(IL.EQ.1)SCALE=Y(1)*2.
  WRITE(NPRNT,1)
  I=40
  M=(IU-1)*10+1
  C
  15 DO 20 K=1,M
  20 IP(K)=IB
  C
  DO 30 J=1,N
  IY=(Y(J)-Y(N))/SCALE+0.5
  IF(IY.NE.1) GO TO 30
  IF(J.GT.IU) GO TO 21
  IX=(IU-J)*10+1
  IP(IX)=IA(1)
  GO TO 30
  C
  21 IF(J.GT.(2*IU)) GO TO 22
  IX=(2*IU-J)*10+1
  IP(IX)=IA(2)
  GO TO 30
  C
  22 IX=(3*IU-J)*10+1
  IP(IX)=IA(3)
  30 CONTINUE
  C
  IF((I/10)*10.EQ.I) GO TO 40
  IF(IP(1).NE.IB) GO TO 35
  WRITE(NPRNT,2)(IP(II),II=2,M)
  GO TO 60
  C
  35 WRITE(NPRNT,3)(IP(II),II=1,M)
  GO TO 60
  C
  40 YP=Y(N)+SCALE*I

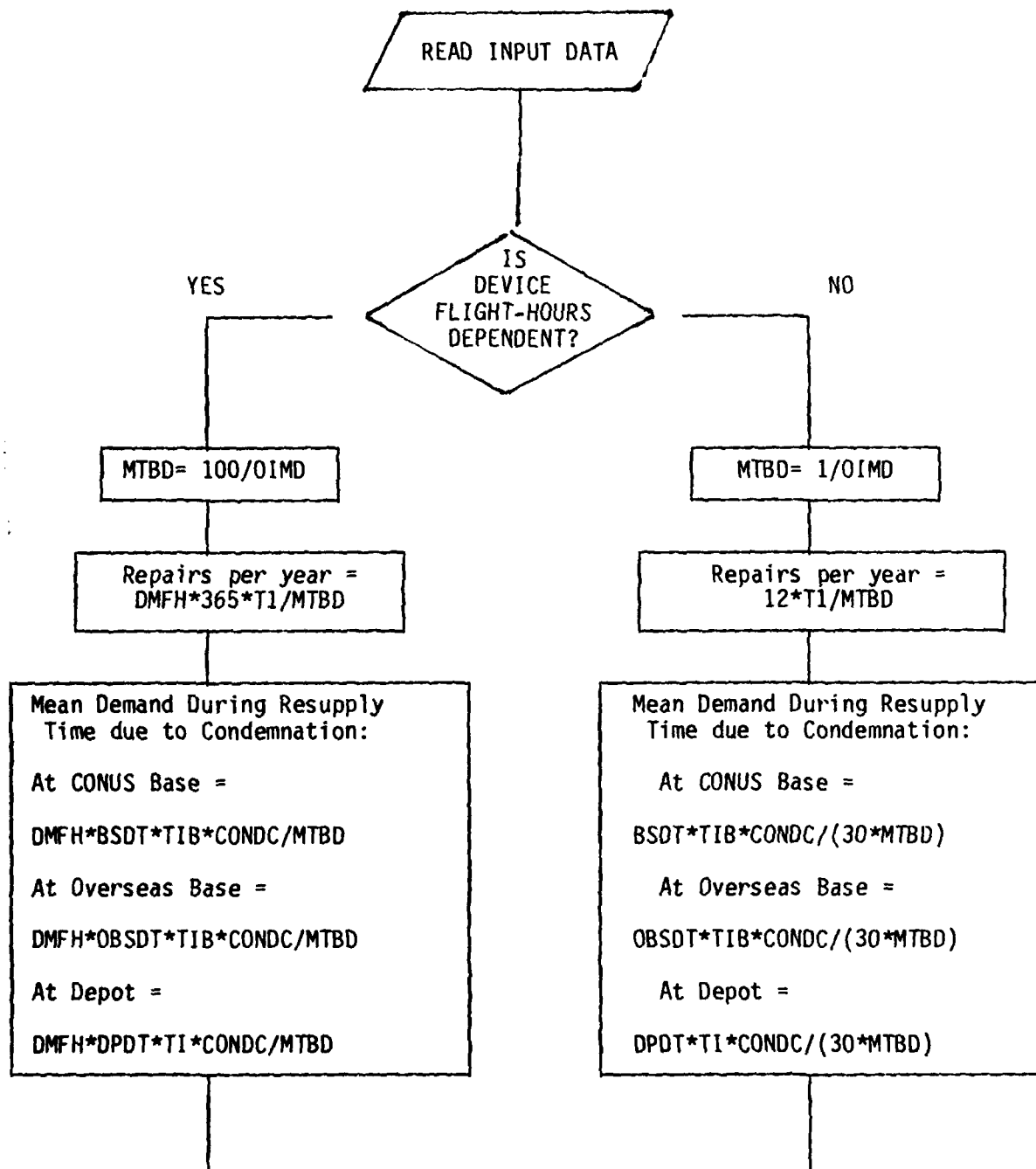
```

```

IF(IP(1).NE.IB) GO TO 45
WRITE(NPRNT,4)YP,(IP(II),II=2,M)
GO TO 60
45 WRITE(NPRNT,5)YP,(IP(II),II=1,M)
C 60 I=I-1
IF(I.GE.0) GO TO 15
C
WRITE(NPRNT,6)
WRITE(NPRNT,7)(X(I),I=1,IU)
IF(NSEL.EQ.2) GO TO 70
WRITE(NPRNT,8)
30 TO 80
70 WRITE(NPRNT,9)
C 80 DO 90 I=1,IL
WRITE(NPRNT,10)IA(I),IC(I)
90 CONTINUE
C
WRITE(NPRNT,11)NINPU,NAME
C
1 FORMAT(1#1#4X,#TOTAL#4X,#COST($)#,/)
2 FORMAT(13X,#**#,90A1)
3 FORMAT(13X,91A1)
4 FORMAT(1X,F10.0,2X,#+,90A1)
5 FORMAT(1X,F10.0,2X,91A1)
6 FORMAT(13X,#+,10(#####))
7 FORMAT(10X,10(F5.2,5X))
8 FORMAT(1X,110X,#BMH(HR.)#/)
9 FORMAT(1X,110X,#DMH(HR.)#/)
10 FORMAT(1X,22X,A1,# REPRESENTS MTBD=F12.2)
11 FORMAT(1X,22X,#FIGURE #,I2,#, 90A1)
C
RETURN
END

```

APPENDIX D. FLOW DIAGRAM OF LCC-LSD ALGORITHM



Mean Demand During Resupply
Time due to Repair:

At CONUS Base =

$$\begin{aligned} & [DMFH*BSDT*TIB* \\ & (1.0-PERC)*(1.0-CONDC)/MTBD] \\ & + [DMFH*BRCT*TIB*PERC/MTBD] \end{aligned}$$

At Overseas Base =

$$\begin{aligned} & [DMFH*OBSDT*TIB* \\ & (1.0-PERC)*(1.0-CONDC)/MTBD] \\ & + [DMFH*BRCT*TIB*PERC/MTBD] \end{aligned}$$

At Depot =

$$\begin{aligned} & DMFH*DRCT+POSB*38.0)*TI* \\ & (1.0-PERC)*(1.0-CONDC)/MTBD \end{aligned}$$

Mean Demand During Resupply
Time due to Repair:

At CONUS Base =

$$\begin{aligned} & [BSDT*TIB*(1.0-PERC)* \\ & (1.0-CONDC)/(30*MTBD)] \\ & + [BRCT*TIB*PERC/(30*MTBD)] \end{aligned}$$

At Overseas Base =

$$\begin{aligned} & [OBSDT*TIB*(1.0-PERC)* \\ & (1.0-CONDC)/(30*MTBD)] \\ & + [BRCT*TIB*PERC/(30*MTBD)] \end{aligned}$$

At Depot =

$$\begin{aligned} & DRCT + (POSB*38.0))* \\ & TI*(1.0-PERC)* \\ & (1.0-CONDC)/(30*MTBD) \end{aligned}$$

Use Poisson distribution (or normal distribution
if demand during resupply time >50) to
calculate initial inventories that
are sufficient with probability SIGMA.

Calculate costs of initial inventories

Calculate costs of installed devices

Calculate annual maintenance cost

Sum to obtain total incremental life-cycle cost

Print results

STOP

LIST OF DEFINITIONS

A = Yearly payment, or annuity (cost of repairs and new items)
 AFLC = Air Force Logistics Command

 BCOND = Average number of condemned items at base at any time
 BCONDO = Average demand per overseas base due to condemnation
 BCONDU = Average demand per CONUS base due to condemnation
 BLR = Base labor wage rate per hour
 BMC = Cost of repair parts or kits (as a percent of unit cost)
 BMH = Base man-hours required to repair item
 BRCT = Time from removal of item until repair at base is complete (days)
 BRPB = Average number of items undergoing repair at base at any one time
 BRPD = Average number of items moving between a base and depot for repair
 at any one time
 BSDT = Time from CONUS base requisition to receipt of new item from depot
 (days)

 CANUMA = Total cost of annual maintenance
 CCONDM = Annual cost of condemnation replacement
 CINIBS = Cost for filling inventory at base level when initiating new system
 CINID = Cost for filling inventory at depot level when initiating new system
 COND = Condemned items (as percent of total demand)
 CONDC = Fraction of demands that are condemned
 1-CONDC = Fraction of demands that are repairable
 CONUS = Continental United States
 CPARTS = Annual repair-parts cost (no parts for condemned items)
 CRANDR = Annual remove-and-replace cost
 CREPB = Annual cost of base repair (condemning and repairing items at base)
 CREPAR = Cost of repair labor
 CREPD = Annual cost of depot repair
 CTALLD = Cost of installed items (No. of item X unit cost)
 CTOILC = Total incremental life-cycle cost
 CTOMAN = Total maintenance cost, over all lifetime

 DCOND = Average number of items on order by depot at any time to replace
 base-condemned items
 DLR = Depot labor wage rate per hour
 DMFH = Flight-hours per day per device
 DMH = Depot man-hours required to repair item
 DMND = Monthly rate-demand
 D039 = Computation system - Equipment item requirements, recoverable,
 serviced at base (anti-G suit)
 D041 = Computation system - Recoverable consumption item requirements
 (oxygen regulator and valve)
 D062 = Computation system - Economic order quantity buy, unrecoverable items
 (oxygen mask and connector)
 DPDT = Time from requisitioning an item from supplier to receipt at depot
 (days)
 DRCT = Time for items to be sent to depot, repaired, and ready for reissue:
 DRCTU, from CONUS bases; DRCTO, from overseas bases
 DRPD = Average number of items undergoing repair at depot at any time

 EOQ = End of quarter

FREQCY = Integer part of PP

i = Annual interest rate

i_f = Inflation rate

i_r = Interest rate

ID = Demand index: ID = 1, flight-hours dependent

ID = 2, calendar-months dependent

IFR = Annual inflation rate as a percent

INT = Annual interest rate as a percent

LAMDAD = Average demand at depot

LAMDBU = Average demand per CONUS base

LAMDBO = Average demand per overseas base

LCC = Life-cycle cost

LCC-LSD = Life-cycle cost model for life support devices

LFT = Assumed lifetime of device, in years

LSC = Logistics support cost

M = No. of bases using item (MO, overseas; MC, CONUS)

MTBD = Mean time between demands (reciprocal of OIMD)

MTBF = Mean time between failures

N = No. of years

OBSDT = Base-depot transit delay (overseas) in days

OIMD = Demand rate for item (per 100 flight-hours or per month, depending on item)

PDM = Programmed (periodic) depot maintenance

PERC = Fraction of repairs done at base

1-PERC = Fraction of repairs done at depot

PERCNT = Percent of item repairs that can be done at base

PFFH = Peak force flying hours (expected fleet flying hours for 1 month during the peak usage period)

POSB = Fraction of bases that are overseas bases

PP = Repairs per year

PW = Present worth

PNT = Fraction of original value by which BMH or DMH decreases with each run

RKIT = Cost of repair parts of kits

RMH = Man-hours required to remove and replace an item at base

SIGMA = Confidence coefficient for inventory

STKBO = Initial inventories needed at overseas base

STKBU = Initial inventories needed at CONUS base

STKD = Initial inventories needed at depot

TI = Total number of items installed

TIB = Total items per base (TI divided by M)

UC = Unit cost of item

