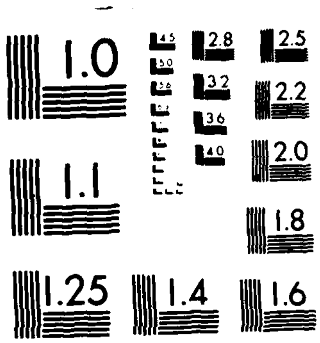
AD-A128 370 DEVELOPING REQUISITION SHORT COST PARAMETERS FOR RIMSTOP (LAMBDA-GENERATOR)(U) ARMY INVENTORY RESEARCH OFFICE PHILADELPHIA PA R DEEMER APR 83 USAIRO-TR-83/1

1/1

UNCLASSIFIED F/G 15/5 NL

END
DATE
FILMED
6-83
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY

AMSAA

AD-
TECHNICAL REPORT
USAIRO-TR-83/1

AMSAA

AD A128370

DEVELOPING REQUISITION SHORT COST PARAMETERS FOR RIMSTOP (LAMBDA-GENERATOR)

INVENTORY RESEARCH OFFICE

April 1983

US Army Inventory Research Office
US Army Materiel Systems Analysis Activity
800 Custom House, 2d & Chestnut Sts.
Philadelphia, PA 19106

83 05 18 046

- Information and data contained in this document are based on the input available at the time of preparation. The results may be subject to change and should not be construed as representing the DARCOM position unless so specified.

ERRATA

The following errors should be corrected in the LAMBDA-Generator report:

1. On Page 9, the letter λ was printed as a g. There are a total of seven places where g should be replaced by a λ. These changes are: line 7, line 9, line 10 of Section 1.1, first paragraph. In Section 1.2, first paragraph, line 1 and line 9 and in the second paragraph the first and second lines also require changes.

2. On page 23, Section 3.1, third paragraph, first sentence should read: ....the Main DSU,....

3. In Appendix B, page 40, expression (1) at top of page should read:

$$\sigma = \sqrt{\text{Max } [I^2,\ (2S-1)OST(AMD)]} \qquad (1)$$

4. In Appendix B, page 41, last expression on bottom of page should read:

$$C_H - (ROP + \frac{OL}{2})(H)(U) \ : \ (\text{Holding cost})$$

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER USAIRO-TR-83/1	2. GOVT ACCESSION NO. AD-A128370	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DEVELOPING REQUISITION SHORT COST PARAMETERS FOR RIMSTOP (LAMBDA-GENERATOR)		5. TYPE OF REPORT & PERIOD COVERED Technical Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert Deemer		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Inventory Research Office, AMSAA Room 800, US Custom House, 2nd & Chestnut Streets Philadelphia, PA 19106		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Materiel Development & Readiness Command 5001 Eisenhower Avenue Alexandria, VA 22333		12. REPORT DATE April 1983 13. NUMBER OF PAGES 60
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Information and data contained in this document are based on input available at the time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the US Army Materiel Development & Readiness Command unless so stated.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Supply Performance
Retail Stockage
Requisitions Short
Budgeting
Safety Levels

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

DoDI 4140.45, Standard Stockage Policy for Consumable Secondary Items at the Intermediate and Consumer Levels of Inventory, requires the Services to determine stockage levels, both which items to stock and how much to stock, at the least cost. Included in the cost considerations is a cost for being unable to fill a requisition, a requisition short cost. This cost is difficult to determine analytically and this report explains an empirical procedure for developing this value based on data about individual items. This data is

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Abstract (continued)

examined for all items in a catalog of a given Army supply site. The procedure for developing the requisition short cost is called the LAMBDA-Generator and is valid for all supply sites within the Army retail system.

ACKNOWLEDGEMENTS

The US Army Materiel Systems Analysis Activity (AMSAA) recognizes the following individual for contributing to this report:

PEER REVIEWER: HERB COHEN

TABLE OF CONTENTS

Next page left blank.

1. BACKGROUND.

In September 1976 a DoD study group reported on analysis of a retail stockage policy [6] which they referred to as RIMSTOP (Retail Inventory Management and Stockage Policy). The group's function was to determine a stockage policy for repair parts at the retail level of supply. The basic model accepted by the DoD group was an economic range and depth model; range being which items to stock and depth being how much of each item to stock. No specific guidelines were given except that range and depth would be determined on economic principles such that a specific target performance would be met. DoD has decided that the RIMSTOP procedures are to be used by all the Services. The Army had developed a range model in 1971 [7] and a depth model [1] was implemented at the wholesale level in 1974. These models were taken as the basis for the Army version of the retail item management stockage policy. Changes were made to these basic models to make them compatible to the retail level of supply.

In May 1978 the Army Inventory Research Office was asked to work on the implementation procedures for RIMSTOP by the Army Deputy Chief of Staff Logistics (DCSLOG). At that time the range and depth models had been pretty well selected, but IRO was asked to develop implementation procedures and insure the efficiency and accuracy of the computation techniques when possible. The actual implementation was divided into two stages: (1) the development of the RIMSTOP process for use in the field by the item manager under various retail procedures (this portion of the project was assigned to the Army Logistics Center (LOGC) and the Army Logistics Systems Support Activity (LSSA)), and (2) the development of the requisition short cost which would be run with the RIMSTOP processes (this portion of the project was assigned to IRO). The process for developing the requisition short cost was derived in close cooperation with the LOGC and LSSA since many of the computations are also used in the RIMSTOP procedures. The retail procedures were developed for three different retail systems: SAILS-ABX, DS4, and ISA. SAILS-ABX refers to stock control accounting for intermediate level of supply including installation, medical, and Corp Support Activities. DS4 refers to stock control activities of both divisional and non-divisional support units that have a direct supply support mission. ISA refers to stock control activities of the DARCOM depot/arsenal systems. The basic models remain the same but the data entered and how the items are stratified are significantly different to necessitate three versions of the basic requisition short cost computation.

The basic depth model minimizes holding and ordering costs subject to a constraint on the number of requisitions short. The range model balances the cost of having the item on the stockage list with the cost of not having the item on the stockage list. Both models use a cost for requisitions short per year. These models are not "coupled", i.e., the same cost structure is not used for both models. However, unlike the wholesale system, the requisition short cost is the same for both models. This report documents the details on developing the requisition short cost.

2. PURPOSE AND OBJECTIVES.

The purpose of this work is to develop an automated procedure by which the Army retail supply system can develop the shortage cost parameters for the range and depth models employed in RIMSTOP. To attain this goal it is necessary to develop a procedure for computing the requisition short cost and then evaluating this cost to see what kind of performance can be expected if that cost is used. The requisition short cost is developed based on target performance set by management. If the projected performance does not meet the overall performance target, then the individual item targets have to be adjusted until the overall target is met. This adjustment to the individual goals is a manual process. The projection of the overall goal given the individual targets is an automatic process.

3. SCOPE AND METHODS.

A general computer program called the LAMBDA-Generator was written to develop the requisition short cost parameter for the RIMSTOP stockage model. Necessary modifications were then made for applications for the various users (SAILS-ABX, DS4 and ISA). Within the user version comparisons were made for different installations to determine if the same parameters could be used or if each installation required unique parameters.

The scope of this work included developing requisition short cost parameters to be used in RIMSTOP computations for SAILS-ABX and DS4. This analysis included collecting data from several installations, developing the requisition short cost parameters and comparing these parameters among installations.

The DARCOM depots under ISA are also using the LAMBDA-Generator program. However, they have proceeded with only consulting help from IRO to assist in setting up and initial operation of the program (IRO supplied the basic program with modifications for ISA use).

4. CONCLUSIONS AND FINDINGS.

To run the RIMSTOP procedures the requisition short cost (λ) must be derived. A computer program written in FORTRAN has been developed to run with the various Army retail level systems -- SAILS-ABX, DS4, and ISA. These procedures vary only in how the λ-values are developed (by what item characteristics), not in the contents of the evaluation.

SAILS-ABX computations for the requisition short cost are defined by four essentiality groupings for medical items (MATCAT C) and three essentiality groupings for any other MATCAT. Only small differences in the overall performance is noted if inappropriate λ-values are used for SAILS-ABX. However, individual classifications yield significantly different cost/effectiveness using these inaccurate λ-values; hence, each SAILS-ABX installation should use λ-values based data from its own items.

DS4 computes the λ-values by three essentiality groupings and six Special Interest Codes (SIC) - a code unique to DS4 users which defines the type of item the Direct Support Unit (DSU) handles. Large discrepancies are noted if the incorrect λ-value is used for DS4 users, both in the individual groupings and the overall projections. Hence, each DS4 user should use λ-values developed from data from that installation.

The ISA activities are using two essentiality groupings and eleven MATCAT groupings. No testing was done on use of inaccurate λ-values. However, since depot functions are so diverse they should be using different λ-values for each installation.

All users of RIMSTOP will compute λ-values based on their own data. SAILS-ABX and DS4 λ-values are determined such that initial fill rates are met for each individual class (essentiality) and type (MATCAT or SIC) of item. For ISA, although using variable initial fill rates to get the λ-values, fill rates were initially adjusted so dollars spent in inventory (requisitioning objective) were the same as the pre-RIMSTOP procedures (Economic Inventory Procedures).

Next page left blank.

CHAPTER 1. OVERVIEW

1.1 Function of Requisition Short Cost Parameter.

When the DoD group met to decide on modelling requirements for retail stockage, the basic supply models accepted were of the economic decision types where the range model was a variation of an ORR, KAPLAN [7] stockage model, and the depth model was a variation of the wholesale level Commodity Command Standard System (CCSS) time-weighted, essentiality weighted, requisition short, type model [1]. To successfully determine range and depth using these models a requisition short cost (g) is required. Since it is very hard to determine this cost objectively, this cost is used as a "tuning-knob", i.e., management specifies a performance target and g is varied until the target is met. The g-generator (LG) is this adjustment process. This procedure is labeled the Supply Performance Analyzer (SPA) at the wholesale level [5]. Instead of "tuning" to performance, the LG can be "tuned" to dollar value of inventory. This makes the LG a valuable budgeting tool and provides backup for the budget procedure.

The requisition short cost represents the implied cost of being out of stock for one requisition for one year, regardless of quantity or cost of the item. The cost per requisition short can vary by the essentiality of the requisition. The more essential the item the higher the requisition short cost will be. Higher essentiality implies a greater need for the item; hence, there is a greater desire to have this item available. To have the item more available implies a greater cost for being without the item and thus more essential items require greater requisition short costs.

1.2 Data Requirements.

The first step in computing the appropriate g-value is getting sufficient data. Since the retail level only keeps one year of demand history at the present time, (SAILS-ABX actually has a smoothed demand value which may cover a longer period) this is what is used. The data should be for every item demanded (stocked or non-stocked) in the past year. Along with the quantity demanded, the number of times the item was requisitioned is also required. The process also needs the unit price of the item, the order-and-ship time of the item (if available), and codes for assigning an individual item to a category for which a g can be determined. The categories are given mostly by type of commodity, e.g., electronics, automotive, medical, or aircraft, combined with the essentiality of the item. The procedure also requires knowledge of the present stockage status of the item, i.e., is it presently a stocked item?

The procedure does not require the use of a previously derived g-value. A range of g-values is examined to yield the best results, i.e., closest to the desired goal.

In addition to the individual item data, installation data are also needed. The data includes:

a. yearly holding cost rate.

b. order cost.

c. fixed cost of stocking an item.

d. processing cost per requisition for item stocked but not available.

e. cost of adding an item to stockage.

f. processing costs per requisition for non-stocked items.

g. fixed removal cost.

h. variable removal cost.

1.3 Assumptions.

As stated earlier, management sets the goals by which the λ-generator functions. These goals are presently set for various essentiality/type of item categories. How the goals are chosen and what categories are stratified is left up to the appropriate personnel. The goals are derived from AR 710-2. The performance goal is initial fill. Initial fill is defined as the percent of all requisitions filled from stock on-hand. As more experience is gained with the operation of the LG the goals of the individual cells of the classification matrix may change to other values. However, the total performance (over all categories) should meet the requirements of AR 710-2.

1.4 Procedures - General.

The λ-generator (LG) is divided into two distinct phases. The first phase finds the appropriate λ-value and the second phase evaluates that particular λ-value. The proper λ-value is the lowest λ-value that projects the performance target being met.

The λ-value is found via a search routine. The entire spectrum of possible λ-values is evaluated for each item before the next item is evaluated. The spectrum of values runs from 25 to 10,000. There are 22 λ-values evaluated for each item. Nothing is done during the first phase to determine which λ-value is the "best" one to use. After all items are evaluated from the demand history data, the best λ-value is derived for each individual cell in the essentiality/type item matrix. The best λ-value is that value which projects the performance to be equal to the target performance. The exact λ-value is determined via a linear interpolation scheme. If it is found that 25 is too high a value to use, 20 is used instead with no further search to determine how close to the target this value will place that category. This is done for simplicity since smaller values will not effect the overall cost/ performance very much.

Once the λ-values are chosen for all cells in the essentiality/type matrix (classification) the projected performance for each item is made. This requires that the data be re-read and the performance projected based on

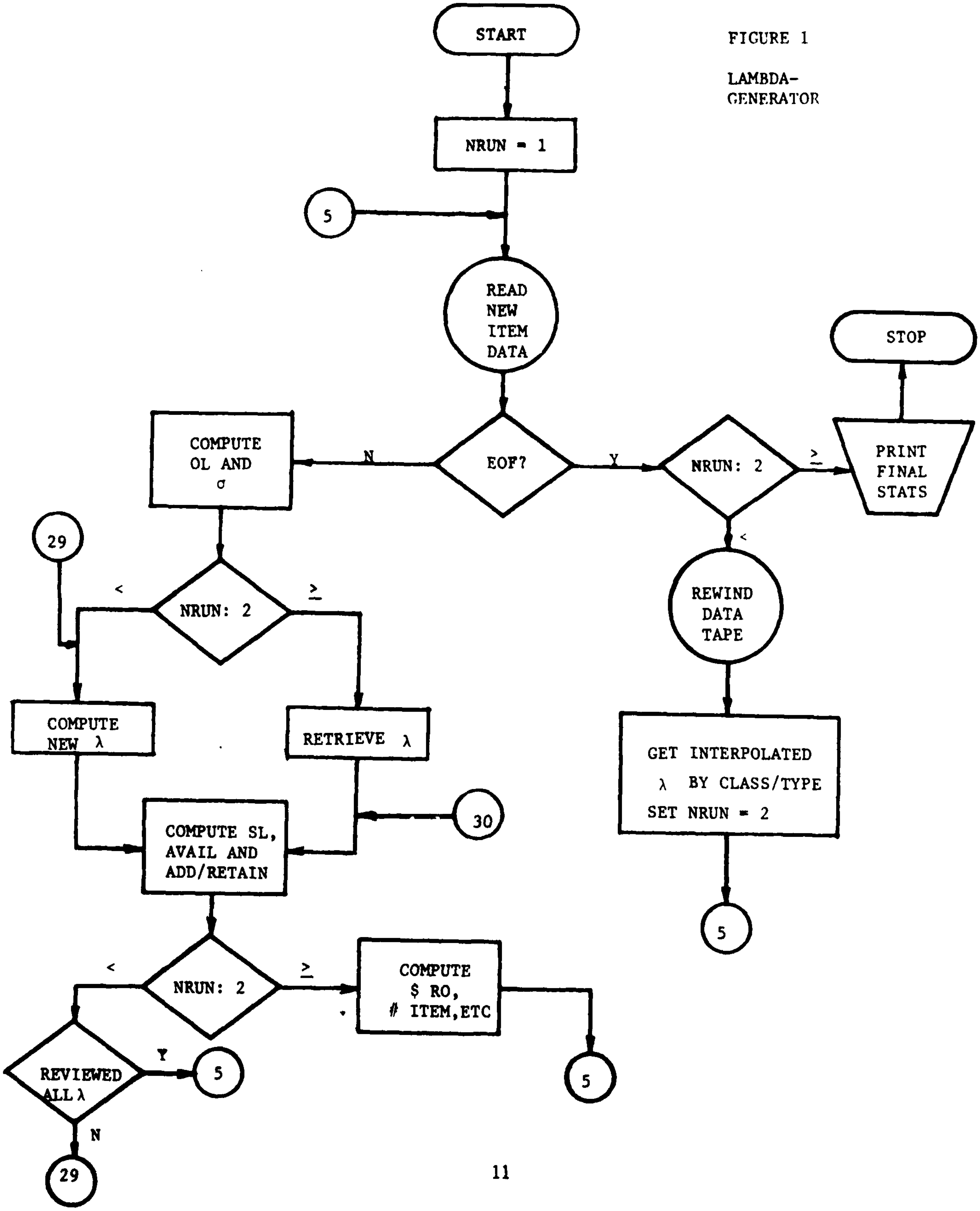


FIGURE 1

LAMBDA-GENERATOR

those exact λ-values which were not evaluated prev· usly.

The overall picture can be observed from Figure 1. NRUN signals whether the λ is being determined(=1) or if the performance is being evaluated.(=2) The performance is indicated by the variable AVAIL. SL, OL,σ and RO stand for safety level, operating level, standard deviation of lead time demand and requisitioning objective respectively. The variable EOF stands for end-of-file and signifies there is no more data.

1.5 Procedures - Specific.

The following procedure is accomplished for every item on the demand history file. The procedure starts with the lowest λ-value allowed, 25. For this value, the safety level, initial fill rate and add/retain criteria are computed. The item frequency is then checked against the add or retain criteria depending on the present stockage status of the item. Depending on this comparison the theoretical satisfaction, accommodation, dollar value of the requisitioning objective, etc, are computed and retained for later use. The λ-value is then increased to some other value and this routine is then repeated. There are 22 λ-values evaluated for each item, the largest being 10,000. (see Appendix A for exact values).

After the 22 evaluations for one item are made the next item is read from the data file and the above process updated. After all the items are read from the data, an evaluation is made by essentiality/type of item grouping. The lowest λ-value is considered first. If the empirical grouping performance (the performance using the given λ-value for that grouping) is above the target a λ-value of 20 is used for that essentiality/type group. The empirical performance is the average of all the items within the group for that particular λ-value. If the target is greater than the empirical value the next λ-value is processed. Each λ-value is evaluated in turn till the target is surpassed. Once the target performance is surrounded, the desired λ-value lies somewhere between the two surrounding values and at this point a linear interpolation is made to choose the best λ-value.

The interpolation ends the process for one essentiality/type grouping. Subsequently, the next grouping is evaluated. After all the groups have been processed the evaluation of each item is made using the derived λ-value for the grouping to which the item belongs. The actual formula for the operating level, safety level, standard deviation of lead time demand, initial fill rate and the add retain criteria are given in Appendix B. A generalized flow chart of the λ process is shown in Figure 2.

1.6 Evaluation.

After all the levels - operating, safety, and add/retain criteria - are computed, the item frequency is compared to the appropriate add or retain stockage criteria. The initial fill is accumulated into the appropriate counter along with safety level, dollars in requisitioning objective stock and the number of stocked items. After all the items are evaluated an essentiality/type performance projection is made for that particular grouping. This procedure is then accomplished for the next group until all the groupings are evaluated.

FIGURE 2. Sequence to Evaluate All λs.

1. Set $\lambda = 500$, $C = \sqrt{20}$, $i = 1$, $j = 1$, $K = 1$, $MAX_1 = 1$

2. $\lambda_1 = \lambda C^{i-3} = 500/(\sqrt{20})^2 = 25$

3. Compute SL, initial fill rate, Add/Retain

4. IF $j \geq MAX_K$ GO TO STEP 7

   otherwise

5. $j = j + 1$

6. $\lambda_j = \lambda_j - 1 + DEL$ GO TO STEP 3

7. $i = i + 1$

8. IF $i > 5$ GO TO STEP 13

   otherwise

9. $K = K + 1$

10. $MAX_K = i(i-1) + 2$

11. $DEL = \dfrac{\lambda C^{i-3} - \lambda_j}{\frac{MAX_K}{2} + I_K}$ where $I_K = 1$ if $K = 2$; 0, 3; -1, 4; -3, 5

12. $j = j + 1$ GO TO STEP 6

13. END

The range of λ values is divided into four intervals. This is done so the values are closer together for smaller numbers and further apart for larger numbers. The four intervals are defined by MAX_K where K runs from two to five (K = 1 defines the beginning value). The values of MAX_K are 1, 4, 8, 14 and 22. For $MAX_K = 1$ the λ value is 25. Thereafter λ is increased by DEL; increments of the intervals are 28.93, 97.05, 289.34, 970.49. Hence, between the first and fourth λ values, λ increases by the amount 28.93; between the fifth and eighth values λ increases by 97.05, etc.

We now wish to determine when we have the correct or "best" λ-value. The goal of setting the λ-value is to meet a target for gross availability or initial fill, i.e., a given level of all requisitions which are filled from stock on hand. However, there are three factors which influence the projected performance of the LG. The analytical computations assume if the item is not stocked there is no stock left over from when it was stocked (indeed if it ever was) that can be used to fill requisitions. If the item is not stocked the LG assumes the stock is immediately taken from the supply organization and must be ordered from the next higher echelon of supply if the need arises. A more accurate reading of the evaluation would be available from a simulator when that situation is encountered where stock could be released in a time-phased manner. The analytic process therefore has a tendency to lower the projected fill rate.

On the other hand, the method of projecting standard deviation of lead time demand was chosen for its simplicity. However, because of the assumptions utilized in developing the simplified formula (see Appendix B), the variation of lead time demand will be lower than expected for the majority of the items. That is the simplified variation will be less than the non-simplified variation. Hence, these computations will have a tendency to raise the projected fill rate.

A third consequence that must be considered is the theoretical expression for computing initial fill. At the wholesale level it has been shown that the prediction of gross availability depends on whether the calculations account for the effect of average requisition size on the reorder point undershoot. The most realistic results are obtained by including the requisition size in the computations. The LG uses the approximation developed by Kaplan [4]. To determine the gross availability, the average requisition size plus the operating level, safety level and the variance of lead time demand must be known. These expressions are developed in Appendix B.

The stock left over for items going off the list cannot be accounted for in a realistic manner. However, by accounting for the other sources of possible error (as discussed above), we can get a fairly accurate prediction of the initial fill rate we could expect to observe.

CHAPTER 2. SAILS-ABX IMPLEMENTATION

2.1 SAILS-ABX Processes.

The Army supply system can be thought of, generally, as being composed of three levels: wholesale, intermediate and user. The wholesale level buys and manages parts for the entire Army. The intermediate level acts as supply buffer for the wholesale system. The user unit is the area where the items are actually used. The Standard Army Intermediate Level Supply Subsystem (SAILS) is the computer supply system for the intermediate level (the ABX refers to modifications to the original SAILS version).

SAILS-ABX stockage levels and criteria are subject to constraints [8] over and above the RIMSTOP constraints. These constraints basically apply to medical items but some apply to non-medical also. The first constraints apply to the operating level. The constraints are by material category code (MATCAT) and apply to the maximum months of supply allowed to the operating level. There is also a minimum month's operating level and a minimum buy quantity. All this is superseded by the fact that all operating levels are greater than or equal to one unit. The SAILS-ABX procedures also have a maximum month's operating level based on the shelf life of the item. SAILS-ABX medical items also restrict the safety level values they will allow. These constraints override the RIMSTOP constraints.

The other constraints on SAILS-ABX items refer to the stockage criteria, i.e., the add and retain criteria. If the organization for which the stockage list is being developed has a user under it which has its own stockage list, something different is done than if the users do not stock their own levels. If any user has a stockage list then prescribed add/retain values are used. If the users do not have their own stockage list the RIMSTOP computations are used. The table of add/retain values is by MATCAT for customers with their own stockage list.

There is another table of add/retain values for medical items alone. Medical items can be totally exempt from RIMSTOP procedures. If the medical item is not stocked at the user level and a certain code is given, the add/retain of the table will be used. This would apply to all medical items and not just to a portion of them. The add/retain values are by unit price and the average inventory priority designator.

At the intermediate level, supplies are placed in storage sites. The customers then get parts from these sites as well as the sites requesting parts to complete their own mission. Any installation can have one or more storage sites.

The storage site is the organization for which the authorized stockage list (ASL) is computed. The storage site is the basic organization upon which the demand data is accumulated to compute the actual RIMSTOP levels.

2.2 Classification of Items.

The reasons there are different versions of the LG are that different users classify the items differently and the data is in different formats. In Chapter 1, Section 4, it was pointed out that the items were to be classified by essentiality and type of item. Essentiality codes are the same for each level of supply; but, any user may desire more subclassification of these categories than another. For example there are essentiality codes:

- B - end item (not essential).
- F - required only in depot level maintenance operations.
- G - not required in support of essential field or organizational maintenance.
- J - required to support maintenance operation but which may be deferred in wartime w/o degradation to the end item (must be performed as soon as operational consideration and parts availability permit).

These items could be classified as inherently the same class of item, i.e., non-essential. However, there could be an argument made to the effect that they are different - the difference being one of degree rather than intrinsic. Since the codes are assigned quite subjectively themselves, it would seem the larger groupings i.e., combining as many codes as possible into one group, would be the best way to classify the items.

The other classification of items is by the type of item. For SAILS-ABX this category was broken down to medical and non-medical. Medical items are identified by MATCAT C. All other MATCATs go into the non-medical category (SAILS-ABX decided not to distinguish between an aircraft item and a tank item; i.e., each weapon system is equally important). Within medical there are four essentiality groupings and within non-medical there are three essentiality groupings. Hence, there are a total of seven λ-values to be generated for each SAILS-ABX user. These groupings are shown in Table 1 along with the initial desired target values of initial fill.

TABLE 1. SAILS Classifications and Targets.

MEDICAL (C)	Essentiality Codes	Target	NON-MEDICAL (OTHER)	Essentiality Codes	Target
Non-essential	G, J, N	.598	Non-essential	B, F, G, J, blank*	.525
N-E II	B, F, blank*	.679	L/S	D, E, S	.60
L/S	D, E, M	.755	Essential	A, C, H	.68
Essential	A, C, K	.825			

2.3 Requisition Short Costs.

In the last section we noted that SAILS-ABX would require seven λ-values per installation. Even though there are several storage sites per installation, each storage site would use the same λ table. In the course

*Although all items are supposed to have essentiality codes, some do not. However, it was also thought that these items should not be excluded from the calculations. Instead these codes should be added.

of developing the procedure for computing the λ-values, data were obtained from several installations. SAILS-ABX planned to use Ft Carson as the lead site to determine feasibility and other characteristics of running RIMSTOP. Therefore, Ft Carson was the first site for which λ-values were determined. These values are shown in Table 2. Medical values are almost all the same (lowest possible value) because the medical constraints override the RIMSTOP constraints and place all safety levels at the lowest level, in this case 15 days. The 15 day constraint on safety level is greater than what might be computed by RIMSTOP; hence, many items have safety levels which are not RIMSTOP computations.

TABLE 2. λ-Values (Ft Carson).

Medical		Non-Medical	
Essentiality	Lambda	Essentiality	Lambda
G, J, N	20	B, F, G, J, blank	700
B, F, blank	20	D, E, S	20
D, E, M	20	A, C, H	1,446
A, C, K	27		

These λ-values were derived using the costs developed by LEA [11] specifically for RIMSTOP implementation (see Appendix C).

In addition to Ft Carson, λ-values were determined for Ft Eustis also. We looked at Ft Eustis because it differs greatly from Ft Carson in the volume of activity, the types of activities and their physical layout. At this point it was not clear whether one set of λ-values could be used for all installations or each installation had to compute its own values. Hence, if the λ-values for these two very different installations were close, it could be assumed that all installations could use the same set of λ- values. The values for Ft Eustis are shown in Table 3.

TABLE 3. λ-Values (Ft Eustis).

	Medical			Non-Medical	
	Essentiality	Lambda		Essentiality	Lambda
Non-essential	G, J, N	--	Non-essential	B, F, G, J, blank	717
N-E II	B, F, blank	--			
L/S	D, E, M	--	L/S	D, E, S	662
Essential	A, C, K	--	Essential	A, C, H	1350

There are no medical items at Ft Eustis but since all the medical values are at their lowest possible rate, safety levels being at their lowest possible value, medical may not vary much from installation to installation. Looking at the non-medical values however, except for the middle category, the values do not appear to vary much. Based on this information alone however, we cannot say whether they are sufficiently close or not. Hence, more information is needed to see if one set of values will suffice or many sets will be necessary.

2.4 Projected Performance.

We have a λ-value now but we do not have any idea what kind of performance we can expect, how much money it will cost or how many items are going to be stocked. Hence, as explained in Chapter 1, Section 4 and 5, there is a second phase to the generator, that is, the projection portion. Running through all the items with the λ-value presented in the last section we get the results shown in Figure 3 for Ft Carson and Figure 4 for Ft Eustis. The information on the charts describes the projected number of items to be stocked (# stock) out of all the items in that particular classification (# items). Then the dollar invested in the requisitioning objective is presented ($RO). The next line of information shows the expected availability or initial fill (AVAIL) if the items are stocked at the levels computed.

The medical categories do not do too well here, i.e., the targets are not met for three of the four categories. This is possible for several reasons. They are: (a) for some groups of items the sensitivity of initial fill in a change in λ is very severe for certain portions of these two parameters (λ and initial fill), i.e., a very small change in λ can mean a very big change in initial fill, (b) the method of determing the λ-value uses a smaller variance of demand than the projection computations; hence, we would expect the projection to yield lower availability values than the generation procedure, and (c) there are many items with only sufficient demand frequency to be added to stockage, but they do not contribute to the initial fill performance since they will not have stock available till more demands occur.

From these results we cannot determine whether there is a need for one set of λ-values good for all SAILS-ABX installations or whether each installation must compute its own values based on its own item catalog and demand history.

2.5 Parameter Interchange.

To ascertain whether one λ-table is sufficient for all users or more than one table is necessary, the λ-values were interchanged between Ft Carson and Ft Eustis. This means that the Ft Carson λ-values (from Table 2) were run through the Ft Eustis data and projections were made as to what would happen. This was reversed with Ft Eustis, i.e., the Ft Eustis λ-values (from Table 3) were used with the Ft Carson data. These results are shown in Figure 5.*

We see that there is an error of from 0.3 percent to 5.4 percent in the RO dollars and approximately a one percent in performance (overall). This is read from Figure 5 where the first three columns of numbers refer to the Ft Carson data. The first column represents the projections if the Ft Carson λ-values are used with the data. The second column represents the projections if the Ft Eustis λ-values are used with the Ft Carson data. The third column represents the percent difference where + refers to the Eustis λ-values giving higher projection than desired and - refers to the Eustis λ-values yielding lower projections than desired. The rows are by

---

* Since Ft Eustis had no medical items, these classifications are not shown.

FIGURE 3. Cost/Performance (Ft Carson - SAILS-ABX).

MEDICAL			NON-MEDICAL		
ESSENTIALITY			ESSENTIALITY		
G, J, N	# stock/# items	109/140		# stock/# items	842/2388
	$RO(X000)	21.65		$RO(X000)	130.80
	Avail	.618	B, F, G, J, blank	Avail	.526
	Target	.598		Target	.525
B, F, blank	# stock/# items	476/547		# stock/# items	57/166
	$RO(X000)	100.23		$RO(X000)	4.84
	Avail	.627	D, E, S	Avail	.698
	Target	.679		Target	.60
D, E, M	# stock/# items	112/144			
	$RO(X000)	23.78			
	Avail	.631	A, C, H	# stock/# items	1478/2662
	Target	.755		$RO(X000)	212.90
				Avail	.684
A, C, K	# stock/# items	1283/1425		Target	.68
	$RO(X000)	230.57			
	Avail	.673			
	Target	.825			
TOTAL	# stock/# items	1980/2256		# stock/# items	2377/5216
	$RO(X000)	376.23		$RO (X000)	348.54
	Avail	.658		Avail	.622

FIGURE 4. Cost/Performance (Ft Eustis - SAILS-ABX).

MEDICAL			NON-MEDICAL		
ESSENTIALITY			ESSENTIALITY		
	# stock/# items			# stock/# items	650/2134
	$RO(X000)			$RO(X000)	57.73
G, J, N	Avail		B, F, G, J, blank	Avail	.526
	Target	.598		Target	.525
	# stock/# items	-		# stock/# items	59/134
	$RO(X000)			$RO(X000)	3.50
B, F, blank	Avail		D, E, S	Avail	.583
	Target	.679		Target	.600
	# stock/# items	-			
	$RO(X000)				
D, E, M	Avail			# stock/# items	1669/3194
	Target	.755		$RO(X000)	155.30
			A, C, H	Avail	.667
	# stock/# items	-		Target	.680
	$RO(X000)				
A, C, K	Avail				
	Target	.825			
TOTAL	# stock/# items	-		# stock/# items	2378/5462
	$RO(X000)			$RO (X000)	216.53
	Avail			Avail	.610

FIGURE 5. Interchange of λ-Values (SAILS-ABX)

NON-MEDICAL

Essentiality		Ft Carson Data: Carson λ	Ft Carson Data: Eustis λ	Ft Carson Data: % Dif	Ft Eustis Data: Eustis λ	Ft Eustis Data: Carson λ	Ft Eustis Data: % Dif
B, F, G J, blank	# stock	842	852	+1.2	650	646	- .6
	$RO	130.80	132.29	+1.1	57.73	57.01	-1.2
	Avail	.526	.529	+ .6	.526	.524	- .4
	Target	.525			.525		
	λ	700	717		717	700	
D, E, S	# stock	57	65	+ 14.0	59	55	- 6.8
	$RO	4.84	11.49	+137.4	3.50	2.95	-15.7
	Avail	.698	.808	+ 15.8	.583	.509	-12.7
	Target	.600			.600		
	λ	20	662		662	20	
A, C, H	# stock	1478	1415	- 4.3	1669	1735	+ 4.0
	$RO	212.9	205.82	- 3.3	155.30	168.35	+ 8.4
	Avail	.684	.675	- 1.3	.667	.680	+ 1.9
	Target	.680			.680		
	λ	1446	1350		1350	1446	
Overall	# stock	2377	2332	- 1.9	2378	2436	+ 2.4
	$RO	348.54	349.60	+ .3	216.53	228.31	+ 5.4
	Avail	.622	.6285	+ 1.0	.610	.614	+ .7

essentiality grouping and then the overall figures. Although the overall numbers do not look too bad, the individual categories can look very bad. It should be pointed out here that the second essentiality grouping has only about 1/10 the number of items in either of the other groups and hence does not account for a very big sample of the total population. However, since it is considered as a group it cannot be disregarded. The essential items (A, C, H) represents the most items and the RO dollars are off three percent and the performance is wrong by about 1.3 percent. Although these are not major errors, the installations should compute their own values.

CHAPTER 3. DS4 IMPLEMENTATION.

3.1 DS4 Processes.

The Direct Support Unit Standard Supply System (DS4) performs the general functions of supply and stock control for the user level. DS4 is a direct support supply management information system that is designed to interface with the Standard Army Maintenance System (SAMS) as well as the intermediate and wholesale system. Since the direct support level of supply connects the user to the entire supply system DS4 must be most responsive to the customer demands. DS4 was designed for quick response through a high level of asset visibility and has been structured wherever possible to be easily understood and used in a routine and automated manner.

DS4 operates in two environments: the Non-divisional Direct Support Unit (DSU), and the Divisional DSU. The original RIMSTOP implementation will be for Divisional DS4. Eventually, the non-divisional will also be incorporated into the RIMSTOP concept. For now however, we will only talk of the Divisional DS4 and how it is broken down for use in RIMSTOP.

The Divisional DS4 is broken down into the Main DS4, Forward DSU's and other DSU's. The Forward DSU receives demands from the field customer. The Forward DSU has stock which it uses to supply its customers and when the Forward DSU supplies reach a certain level, the Forward DSU will order from the Main DSU for the amount needed to bring its stock up to the appropriate level. For RIMSTOP implementation this has been interpreted to mean that both the Main and Forward DSU's will have demand supported stockage lists. The Forward DSU demands are from the customers directly and the Main DSU's demands are the consolidation of the Forward DSU demands and its own customers. The DS4 system is linked to the next higher level of supply, SAILS-ABX, and some demands may go directly to SAILS-ABX and not through the DS4 system. We need not be concerned about that aspect at this time.

3.2 Classification of Items.

DS4 uses the same essentiality groupings as SAILS-ABX non-medical. This was not intentional, but both activities decided on this grouping after examination of the codes on an individual basis. The basic groupings are: non-essential (codes B, F, G, J, blank), legal and safety (codes D, E, S) and essential (A, C, H). These codes have the same meaning as the codes used in the SAILS-ABX procedures (see Appendix D).

The type of item stratified by DS4 is based on the Special Interest Code (SIC). The SIC indentifies specific groups of items the DSU is handling. These codes are unique to DS4 users and can be found in TM 38-L32-13-3, Appendix A, "Functional Users Manual for DS4". There are six basic categories of SIC's which DS4 uses in the classification matrix. These codes are:

- A - aircraft (applicable at aircraft DSU, i.e., DSU's whose main concern is aircraft maintenance and support).
- M - missile (applicable at missile DSU).
- C - common (applicable to DSU's other than aircraft and missile).
- T - Class II items.

J - Class III items.
F - Class IV items.

The classification matrix of DS4 along with the initial performance targets is shown in Table 4.

All the SIC classes have the same targets although they change by essentiality code. These values could change as more experience is gained in setting the values in coordination with meeting overall goals.

TABLE 4. DS4 Classification and Targets.

Essentiality Codes	SIC C	A	M	T	F	J
Non-essential						
B, F, G, J, blank	.60	.60	.60	.60	.60	.60
Legal/Safety						
D, E, S	.65	.65	.65	.65	.65	.65
Essential						
A, C, H	.70	.70	.70	.70	.70	.70

3.3 <u>Requisition Short Costs</u>.

The 18 λ-values to be computed for DS4 are based on demands for all items which pass through the DS4 stock control procedure. The stockage list developed using the results of the LG will be applied to all stockage points within the installation, i.e., Main and Forward DSU's. DS4 plan of implementation of RIMSTOP has Ft Carson as the lead site. Table 5 shows the λ-values determined for the Ft Carson DS4 data. The "-" indicates there were no items with demand in that category (legal/safety, aircraft). These λ-values were developed with the costs developed by LEA [11] (see Appendix C).

TABLE 5. λ-Values (Ft Carson).

Essentiality	SIC C	A	M	T	F	J
Non-essential						
B, F, G, J, blank	1865	1929	5148	1810	2655	283
Legal/Safety						
D, E, S	20	-	3330	2325	1828	2554
Essential						
A, C, H	20	2978	9030	1158	4177	94

In addition to Ft Carson, λ-values were also determined for Ft Campbell. We looked at Ft Campbell because, as before with SAILS-ABX, we wanted to compare λ-values for two installations to see how they varied and because

Ft Campbell has been under DS4 the longest amount of time. Ft Campbell λ-values are shown in Table 6.

TABLE 6. λ-Values (Ft Campbell).

Essentiality	SIC					
	C	A	M	T	F	J
Non-essential						
B, F, G, J, blank	20	4039	2428	1389	1578	421
Legal/Safety						
D, E, S	20	-	-	4445	-	-
Essential						
A, C, H	71	740	9999	1297	2403	139

The difference between the λ-values in some instances is rather big and not so vast in others. Again, however, it is difficult to decide if there is a significant difference just by looking at the λ-values.

3.4 Projected Performance.

To determine how well the λ-values produced in the last section are actually doing, the various costs and performance values are shown in Figure 6 (Ft Carson) and Figure 7 (Ft Campbell). Figures 6 and 7 are read just as in Section 2.4. We notice here however, that the target initial fill values are rarely met. This has mainly to do with the variance computation. The computation used to develop λ is the same as RIMSTOP. However, what is believed to be the more accurate computation of variance [see 3] is also a slightly more complicated process. The variance was adopted by RIMSTOP because of ease of computation and it is not very much different than the more involved process. The LG uses the RIMSTOP variance computation to compute λ but uses the more involved and the more accurate expression to evaluate that particular λ-value. Since the approximation is for the most part projecting lower variance than the more realistic expression, the projected performance for the more exact expression will be lower than the approximate value.

3.5 Parameter Interchange.

To determine the effect which the wrong λ-value has on the operation of the DSU, we performed the same analysis on the DS4 λ-values as on the SAILS values. The λ-values developed for Ft Carson were run through the Ft Campbell data and vice versa. These results are shown in Figure 8 and Figure 9.

Interchanging the λ-values greatly effects the statistics at the DSU level of supply. Over all we can expect a difference of about 5 percent in the performance, over 19 percent difference in dollars spent in inventory, and approximately 35 percent difference in the number of items to be stocked. This kind of error cannot be ignored. Hence, all users for DS4 should develop and use values based only on their data.

Figure 6. COST PERFORMANCE (FT CARSON) DS4.

Essentiality		SIC C	A	M	T	F	J
Non-essential B, F, G, J, blank	# items/# stock	- 7133/3447	83/34	164/162	886/276	70/66	17/6
	$RO(X000)	- 337.7	5.3	21.9	78.1	18.4	3.6
	I. F.	- .589	.584	.533	.581	.542	.614
	Target	- .60	.60	.60	.60	.60	.60
Legal/Safety D, E, S	# items/# stock	- 324/66	-	2/2	25/23	2/2	2/2
	$RO(X000)	- 7.1	-	.4	3.1	.3	.8
	I. F.	- .631	-	.629	.621	.602	.567
	Target	- .65	-	.65	.65	.65	.65
Essential A, C, H	# items/# stock	- 9537/2728	926/878	170/163	631/256	52/52	86/55
	$RO(X000)	- 246.5	168.2	89.3	149.1	5.4	37.7
	I. F.	- .706	.691	.631	.681	.622	.618
	Target	- .70	.70	.70	.70	.70	.70

Figure 7. COST PERFORMANCE (FT CAMPBELL) DS4.

Essentiality		SIC C	A	M	T	F	J
Non-essential B, F, G, J, blank	# items/# stock	- 5251/1533	214/103	53/24	894/424	71/44	36/19
	$RO(X000)	- 186.7	42.5	35.3	151.0	13.2	5.4
	I. F.	- .597	.595	.585	.601	.600	.671
	Target	- .60	.60	.60	.60	.60	.60
Legal/Safety D, E, S	# items/# stock	- 243/97	1/0	-	21/18	-	-
	$RO(X000)	- 15.8	-	-	1.7	-	-
	I. F.	- .764	-	-	.635	-	-
	Target	- .65	-	-	.65	-	-
Essential A, C, H	# items/# stock	- 5951/2005	3047/1858	179/161	722/412	74/57	115/80
	$RO(X000)	- 316.0	791.6	89.2	250.3	24.5	55.6
	I. F.	- .683	.690	.692	.692	.647	.675
	Target	- .70	.70	.70	.70	.70	.70

Figure 8. INTERCHANGE OF λ-VALUES, FT CARSON (DS4).

		CARSON λ			CAMPBELL λ		
		I.F.	$RO(X000)	# Stock	I.F.	$RO(X000)	# Stock
Common CLASS IX	ESS	.706	246.5	2728	.734	331.5	2777
	L/S	.631	7.1	66	.631	7.1	66
	N-E	.589	337.7	3447	.394	36.8	599
	AVG	.669			.631		
A/C CLASS IX	ESS	.691	168.2	878	.614	100.9	397
	L/S	-	-	-	-	-	-
	N-E	.584	5.3	34	.643	164	82
	AVG	.683			.617		
MISS CLASS IX	ESS	.631	89.3	163	.631	89.3	163
	L/S	.629	.4	2	.586	.1	1
	N-E	.533	21.9	162	.453	13.1	71
	AVG	.587			.550		
CLASS II	ESS	.681	149.1	256	.689	152.6	263
	L/S	.621	3.1	23	.735	3.1	25
	N-E	.581	78.1	276	.568	73.0	263
	AVG	.635			.635		
CLASS IV	ESS	.622	5.4	52	.414	4.3	49
	L/S	.602	.3	2	-	-	-
	N-E	.542	18.4	66	.477	15.9	30
	AVG	.571			.445		
CLASS III	ESS	.618	37.7	55	.697	48.8	60
	L/S	.567	.8	2	-	-	-
	N-E	.614	3.6	6	.622	3.9	6
	AVG	.618			.691		
TOTAL		.665	1172.9	8218	.631	941.8	4852
					-5.1%	-19.7%	-41.0%

Figure 9. INTERCHANGE OF λ-VALUES, FT CAMPBELL (DS4).

		CAMPBELL λ I.F.	CAMPBELL λ $RO(X000)	CAMPBELL λ # Stock	CARSON λ I.F.	CARSON λ $RO(X000)	CARSON λ # Stock
Common	ESS	.684	312.2	1992	.636	217.0	1937
CLASS	L/S	.764	15.8	96	.764	15.8	97
IX	N-E	.591	186.8	1533	.755	532.1	3273
	AVG	.645			.695		
A/C	ESS	.690	829.5	1875	.762	1598.4	2843
CLASS	L/S	-	-	-	-	-	-
IX	N-E	.583	73.5	203	.544	52.5	123
	AVG	.684			.750		
MISS	ESS	.664	124.8	178	.660	115.7	177
CLASS	L/S	-	-	-	-	-	-
IX	N-E	.586	81.0	29	.638	126.7	51
	AVG	.648			.655		
	ESS	.692	249.5	411	.679	230.7	396
CLASS	L/S	.654	5.2	21	.596	1.6	14
II	N-E	.602	146.4	439	.623	153.9	471
	AVG	.650			.653		
	ESS	.647	24.1	54	.743	46.9	74
CLASS	L/S	-	-	-	-	-	-
IV	N-E	.599	13.0	42	.642	13.2	49
	AVG	.627			.700		
	ESS	.675	56.7	80	.610	45.9	77
CLASS	L/S	-	-	-	-	-	-
III	N-E	.669	5.4	19	.652	5.0	18
	AVG	.674			.614		
TOTAL		.651	2123.9	6972	.698	3155.4	9600
					+7.2%	+48.6%	-37.7%

CHAPTER 4. ISA IMPLEMENTATION

4.1 ISA Processes.

The Installation Supply Account (ISA) is the supply and stock control procedure for the Army Materiel Development and Readiness Command (DARCOM) retail supply structure which includes depots, arsenals, and proving grounds. The depots are the primary maintenance and overhaul facilities in the Army supply structure. Although the ISA's are quite different in scope and structure from both SAILS and DS4, the ISA is included within the scope of RIMSTOP.

The depots have two basic functions: (a) act as a warehouse for the wholesale level supplies and (b) act as a maintenance activity for major repair/overhaul functions which the other activities cannot handle. The warehousing function is independent of the maintenance function and is not included in the ISA scope of functions. Hence, the warehousing function is excluded from all discussion about RIMSTOP.

SAILS and DS4 users do some repair themselves, but basically, they do a pull and replace type of maintenance; whereas, the depots repair the items that the other activities pulled. The depots also pull and replace certain modules but they also repair/overhaul these modules themselves.

Under the ISA system each depot is independent of any other and only has its own stockage to be concerned about. There are exceptions to this in that there are some depots that do all the accounting for other, smaller, depots. The main depot bases its stockage list on the total demand and then the main accounting depot either keeps all the stock and hands it out as needed or gives the other depot supplies by percent of demand or a similar non-complex rule. Under these satellite depot procedures only the main accounting depot has a stockage list. Within the depot activities various maintainence shops have their own stock, called shop stock, which is drawn from the ISA stock. The shop stock demands help make up the requirements for the ISA demand profile.

The arsenals are different from the depots in that the arsenals are basically manufacuturing organizations, run training schools and supply the installation with basic supplies to carry on their operations.

4.2 Classification of Items.

Like the previous two users, SAILS and DS4, ISA decided to stratify their items by essentiality and MATCAT. However, ISA is using only two essentiality groupings: nonessential (codes B, E, G) and essential (codes A, C, D, F, J, K, M, N). ISA is using 11 MATCAT categories. The depots and arsenals combined will cover all the types of items in the Army catalog. However, any one depot/ arsenal will not be heavily involved with all or even most of them. They will specialize in certain areas and as a result the MATCAT's of real concern will vary by depot/arsenal. Hence, the more active MATCAT's can be better protected and the less active can have lower performance targets without impairing the overall performance of the depot. Thus, the ISA classification matrix is divided into more types than the others (SAILSABX, and DS4).

The initial ISA classification matrix and performance targets are shown in Table 7. Until more experience is gained in setting the targets it was decided to use the same goal for all classes of items. The matrix also shows three categories where there are two MATCAT's grouped together. These represent similar items and therefore are grouped as shown.

TABLE 7. ISA Classifications and Targets.

Essentiality	MATCAT										
	E	F	H	K	L	M	R	T	(BJ)	(GQ)	(PU)
Non-essential											
B, E, G	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
Essential											
A, C, D, F, J, K, M, N	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6

TABLE 8. λ-Values, Letterkenny Army Depot.

Essentiality	MATCAT										
	E	F	H	K	L	M	R	T	(BJ)	(GQ)	(PU)
Non-essential											
B, E, G	276	2236	299	20	9030	5148	59	52	20	929	-
Essential											
A, C, D, F, J, K, M, N	284	2236	4177	7088	10000	10000	767	20	10000	227	209

4.3 Requisition Short Costs and Performance.

ISA personnel from DARCOM, Letterkenny Army Depot, and Depot Systems Command (DESCOM) did not want to have more dollars spent in requisitioning objective (RO) for RIMSTOP than the present system - Economic Inventory Procedure (EIP). After several trials the same approximate cost was projected and the λ-values of Table 8 were derived. These values were derived from the target performance values of Table 7. The EIP procedures were run through the same data and the statistics shown in Table 9 were the result:

TABLE 9. EIP versus RIMSTOP.

	EIP	RIMSTOP
# lines	7825	8943
$ RO(MIL)	29.3	28.9
$OL(MIL)	16.7	16.2
$SL(MIL)	.48	.53

These figures show that RIMSTOP procedures will stock more items for the same dollars in RO. This implies RIMSTOP will in general stock inexpensive items and not the more expensive items unless they have relatively large requisition frequencies.

No testing was done on ISA data to determine if the same λ-value could be used at different depots. Since each depot/arsenal has special areas of concern, the classification matrix was made large and it was decided that all depots/arsenals would use the same matrix and customize the λ-values to their own use by running their data through the LG. The cells of most concern to any ISA would be the cells for which the most activity would be observed. The LG would basically determine the λ-values for these areas and the other cells could, if necessary, be manually adjusted from the automated output of the LG. Figure 10, for example, shows the statistics for individual cells for the Letterkenny data. We see from this that only four of the categories (E, T, BJ, GQ) account for 85 percent of the items with demand. Furthermore, they account for 58 percent of the dollars in RO. Hence, if Letterkenny concentrates on these items by increasing the target performance for these groups, the overall performance can be achieved at a minimum increase in dollars spent in inventory.

FIGURE 10. ISA Cost Performance, Letterkenny Army Depot.

Essentiality		MATCAT E	F	H	K	L	M
Non-essential B, E, G	# Items/# Stock	887/522	242/114	6/3	533/138	227/98	101/37
	$RO (X000)	180.9	67.3	.5	31.4	60.3	39.3
	Avail	.573	.476	.585	.681	.318	.499
	Target	.60	.60	.60	.60	.60	.60
Essential A, C, D, F, J, K, M, N	# Items/# Stock	2067/967	112/55	32/8	277/100	377/155	333/153
	$RO (X000)	233.6	45.0	3.9	70.7	329.6	155.8
	Avail	.584	.549	.328	.442	.347	.463
	Target	.60	.60	.60	.60	.60	.60

Essentiality		MATCAT R	T	(BJ)	(GQ)	(PU)
Non-essential B, E, G	# Items/# Stock	36/21	1163/422	723/78	1136/648	-
	$RO (X000)	308.6	53.4	13.9	267.5	-
	Avail	.491	.571	.226	.583	-
	Target	.60	.60	.60	.60	-
Essential A, C, D, F, J, K, M, N	# Items/# Stock	197/114	3020/1267	2374/1059	2805/1003	4/2
	$RO (X000)	178.1	139.7	757.8	181.3	.2
	Avail	.562	.708	.575	.573	.550
	Target	.60	.60	.60	.60	.6

APPENDIX A

LAMBDA VALUES EVALUATED

Next page is blank.

LAMBDA VALUES EVALUATED

Number	LAMBDA	NUMBER	LAMBDA
1	25.	12	1657.4
2	53.9	13	1946.7
3	82.9	14	2236.1
4	111.8	15	3206.6
5	208.8	16	4177.1
6	305.9	17	5147.5
7	402.9	18	6118.
8	500.	19	7088.5
9	789.3	20	8059.
10	1078.7	21	9029.5
11	1368.	22	10000.

Next page is blank.

APPENDIX B

COMPUTATION OF SUPPLY LEVELS AND PERFORMANCE EVALUATION

Next page is blank.

COMPUTATION OF SUPPLY LEVELS AND PERFORMANCE EVALUATION

The RIMSTOP computations can be divided into three categories for the λ-Generator. They are the depth of stockage, the expected performance if the item is stocked and the range criteria for stockage.

Let us first examine the depth of stockage, i.e., how much of each item to stock, since this information is used in the other two computations. The operating level (OL) is computed first. This is the straight Wilson Square Root formula:

$$OL = \sqrt{\frac{2(D)\ (O)}{U\ (H)}}$$

where D - average yearly demand
O - order cost
U - unit price of item
H - annual holding cost rate

In addition, OL $\leq$ D and OL $\geq$ 1 unit.

After the OL is computed a standard deviation of lead time demand (σ) is computed. This uses the forecast percent error table developed by Hutchison [3] which assumes a negative binomial distribution of lead time demand. The table is:

PERCENT ERROR (PCER)

Annual Frequency	Annual Dollar Demand <200	Annual Dollar Demand ≥200
<5	2.09	1.63
5 - 8.99	1.78	1.35
9 - 16.99	1.44	1.26
17 - 32.99	1.17	1.01
33 - 62.99	.865	
63 - 121.99	.704	
≥122	.477	

Then, the incomplete standard deviation of lead time demand is given by

$$I = \sqrt{2}\ (PCER)\ (OST)\ (AMD)\ [OST]^{-.237}$$

and the complete standard deviation is given by

Stuttering Poisson: R. M. Adelson, "Compound Poisson Distributions" from Operational Research Quarterly, Vol 17, No. 1, 1966, pgs 73 to 75.

Camp Paulson: J. J. Bartko, "Approximating a Negative Binomial" from Technometrics, Vol 8, No. 2, 1966, pgs 345 to 350.

$$\sigma = \sqrt{\text{Max } [I^2 \quad (2S-1) \text{ OST (AMD)}]} \qquad (1)$$

where OST - order-ship-time (months)
S - average requisition size
AMD - average monthly demand

This last term is needed because the preceding PCER table did not evaluate frequencies below 3 and the preceding table does not indicate the actual variability encountered for these very low frequencies. The (2S-1) OST(AMD) expression is the theoretical variance evaluation assumming a Stuttering Poisson demand probability distribution. The Stuttering Poisson distribution assumes Poisson demand and geometric order sizes.

This is the more precise method of obtaining the standard deviation of lead time demand. However, the decision was made to use a more simple expression to compute the variability. This simpler evaluation used PCER = 1 everywhere and assummed the exponent .237 was equal to .5. Using these values and some algebraic manipulation we get:

$$\sigma = .769 \text{ (AMD) } [\text{OST } (30)]^{.5} \qquad (2)$$

The expression (2)is used to derive the λ-value and expression (1) is used to evaluate the λ-value thus derived. This was done because (1) is more accurate and the projections should be as accurate as possible.

Once the OL and σ are known the safety level (SL) can be computed. It was stated in the beginning of RIMSTOP that negative safety levels would be allowed. Hence, the computations do allow negative safety levels but they are somewhat biased toward positive values because of the probability distribution used. The safety level is

$$SL = a\sigma$$

where

$$a = -\frac{1}{\sqrt{2}} \text{Ln} \left[\frac{\sqrt{2}(OL)(H)(U)(S)}{.5\lambda(\sigma) \left(1-\exp(-\sqrt{2}(OL)/\sigma)\right)} \right] \qquad (3)$$

In addition SL = min [OST (AMD), 3σ, SL]

The expected performance for a stocked item, the satisfaction, i.e., the percent of requisitions for stocked items which can be filled from stock onhand, can now be computed assuming the item is stocked to its full requisitioning objective: RO = SL+OST(AMD) + OL. The satisfaction is computed using Kaplan's [4] approximation to the Fraction of Demand Satisfied Without Backorder (FDSWB) which makes use of the fact that not all requisitions are of unit size. Kaplan's approximation makes use of the Camp - Paulson approximation to the Negative Binominal probability distribution. The satisfaction is then:

$$SAT = \frac{1}{OL + S-1} \{ (1-q^{R+1})G(R-z,\ OL+3) + q^{R+1}G(0,\ R+OL) \}$$

where

$$z = \frac{1}{1-q^{R}} \left\{ \frac{1}{p} - q^{R} \left[R+\frac{1}{p} \right] \right\}$$

and p and q are the parameters of the geometric distribution (the number of units per requisition is represented by the geometric distribution):

$$h(s) = pq^{s-1} \qquad p+q = 1 \qquad 0< p,q< 1$$

and G(R, OL) - satisfaction assuming every deficit, z, below the Reorder point, R, is zero. A deficit is the amount by which the stock level is below R when an order is placed.

The probability distribution used to evaluate G(.,.), the complimentary cumulative function, is the negative binomial to which the Camp-Paulson approximation is applied. Even though the Camp-Paulson is not a very good approximation for small means, viz, less than 3, experimentation indicated the approximation gave only slightly different results (cost versus performance) over a whole catalog of items compared to using the exact Negative Binomial for these small demand items. Since the approximation takes significantly less computer time it was decided to go with the approximation initially.

There is now enough information available to compute the add/retain criteria which will determine the range of items to be stocked. These computations are what shall be called the Deterministic Economic Stockage Model. An unstocked item shall be stocked if the annual frequency is greater than or equal to the add criteria. A stocked item shall remain stocked if it is greater than or equal to the retain criteria. The computations are:

$$a = \frac{F + C_H + C_A + C_O}{(\lambda + C_{XN}) - \mu(\lambda + C_{XS})}$$

and

$$r = \frac{F + C_H - C_R + C_O}{(\lambda + C_{XN}) - \mu(\lambda + C_{XS})}$$

where

a - add criteria

r - retain criteria

F - fixed cost of stocking an item

C_H - $(ROP + \frac{OL}{2} (H)(U))$: (Holding cost)

ROP - reorder point (SL + OST (AMD))

C_A - cost of adding an item to stockage

C_o - $0\frac{D}{OL}$: (order cost)

C_{XN} - processing cost per requisition for non-stocked item

μ - 1-satisfaction (implemented as 1 - TARGET FILL)

C_{XS} - processing cost per requisition for item stocked but not available

C_R - $(ROP + \frac{OL}{2})(U)(VRC) + FRC$: (Removal cost)

VRC - variable removal cost rate

FRC - fixed removal cost

The initial version of the λ-generator will have a variable removal cost rate of zero (0).

APPENDIX C

COSTS FOR RANGE AND DEPTH MODELS

Next page is blank.

COSTS FOR RANGE AND DEPTH MODELS

	SAILS	DS4	ISA
Yearly Holding Cost Rate	.31	.25	.24
Order Cost	10.58	15.10	30.00
Maintain Item in Stock for 1 Year	7.83	30.00	6.50
Add Item to Stockage	179.78	187.00	10.00
Remove Item from Stockage	166.04	125.00	10.00
Process Requisition for Stocked BUT Unavaliable Item	4.41	4.82	2.00
Process Requisition for Non-stocked Item	4.26	2.36	13.00

The SAILS and DS4 values were developed by LEA [11]. The ISA costs were developed by the Army Logistics Systems Support Activity (LSSA). These costs were approved for use in RIMSTOP in a 29 July 1981 letter (1st Indorsement) from DARCOM Headquarters (DRCIS-S) to LSSA (DRXLS-LGS). The subject of the letter was RIMSTOP.

Next page is blank.

APPENDIX D

ESSENTIALITY CODES

Next page is blank.

ESSENTIALITY CODES

1. A one-position, alpha code prescribed by AR 708-1 which indicates whether an item is essential.

a. Codes A and B identify an item contained in authorization and allowance media other than repair parts and special tools listed (RPSTL) or an item excluded from the provisions of AR 700-18.

b. Codes C, D, E, F, G, H, S, and L are applicable to items contained in repair parts and special tools lists (RPSTL) of the equipment technical manual; assigned on the basis of the support item's application to an end item; however, the CML reflects only the last essentiality code assigned to the support item.

2. This code is received from the USA catalog data agency and is a mandatory entry in the availability balance file-catalog fixed header (record position 44) and the catalog master data file (record position 36).

Code	Explanation
A	Item is essential.
B	Item is not essential.
C	A repair part required to support a maintenance operation, at a field maintenance or organizational maintenance level, that must be performed to insure that the end item continues to be capable of performing its intended combat or combat support mission. Essential.
D	A repair part that is not required in support of an essential field maintenance or organizational maintenance function (code C) but is required for operator/crew safety during training and/or in garrison. Safety.
E	A repair part that is not required in support of an essential field maintenance or organizational maintenance function (code C) but is required to meet climatic conditions or to meet legal requirements, or the requirements of a host nation in an overseas environment. Legal/climatic.

Code	Explanation
F	A repair part that is only used in depot maintenance operations.
G	A repair part that is not required in support of an essential field maintenance or organizational maintenance function (code C), or for the operator safety (code D), or legal requirements (code E), or deferrable maintenance operation (code F). Not essential.
H	A support item or repair part whose lack renders the supported or end item inoperable.
J	A repair part that is not required in support of an essential field maintenance or organizational maintenance function but is required to support a wartime deferrable maintenance operation, which would not cause degradation of the end item to the extent that it is unable to perform its operation but must be performed as soon as operational considerations and parts availability permit.
S	A support item or repair part not qualified for classification as code H but which is needed to:

a. Satisfy legal, climatic, or other requirements peculiar to the planned operational environment of the supported item.

b. Minimize or eliminate safety hazard to the operator or crew of the supported item.

c. Preclude the creation of a hazardous condition within the vicinity of the supported item.

d. Prevent the impairment of or the temporary reduction in effectiveness of operation of the supported item because of a lack of servicing type items such as oil and air filter elements or filters.

Code	Explanation
L	A support item or repair part not qualified for placement in essentiality code H or S and for medical repair parts.

Essentiality codes assigned to medical secondary items.

Code	Explanation
B	Medical materiel considered routine for health care and diagnosis.
K	Medical materiel considered essential for maintaining life support.
M	Medical materiel considered necessary for maintaining life support.
N	Medical materiel considered supplementary for health care.

NOTE: Essentiality codes H, S, and L are replaced by C, D, E, F, and G, but will remain on the master file until removed through normal attrition. This will take place as changes are broadcast by CDA and applied to the file during the monthly catalog change process.

Next page is blank.

APPENDIX E

ARMY MATERIEL CATEGORY CODES

Next page is blank.

ARMY MATERIEL CATEGORY CODES

Section I. MATERIEL CATEGORY AND INVENTORY MANAGER OR NICP/SICC

ALPHA CODE	MATERIEL CATEGORY	INVENTORY MANAGER OR NICP/SICC AND LOCATION
B	Ground Forces Support Materiel (Other Support Materiel)	US Army Troop Support and Aviation Materiel Readiness Command, St Louis, MO 63120
C	Medical/Dental Materiel[1]	Office of the Surgeon General US Army Medical Materiel Agency Frederick, MD 21701
D	Single Manager Ammunition	US Army Armament Materiel Readiness Command, Rock Island, IL 61299
E	General Supplies (DLA/GSA items)[1]	US Army General Materiel and Petroleum Activity, New Cumberland, PA 17070
F	Clothing Textiles and Non-Medical Toiletries (DLA/GSA items)[1]	US Army Support Activity, Philadelphia, PA 19101
G	Communications and Electronics Equipment. Electronics Materiel[1]	US Army Communications and Electronics Materiel Readiness Command, Directorate of Materiel Management, Fort Monmouth, NJ 07703
H	Aircraft, Air Materiel[1]	US Army Troop Support and Aviation Materiel Readiness Command, St Louis, MO 63120
J	Ground Forces Support Materiel (DLA/GSA items)[1]	US Army General Materiel and Petroleum Activity, New Cumberland, PA 17070
K	Tactical and Support Vehicles, Combat and Automotive Materiel[1]	US Army Tank-Automotive Materiel Readiness Command, Warren, MI 48090

A-1

ALPHA CODE	MATERIEL CATEGORY	[illegible] NICP/ SICC AND LOCATION
I	Missiles Missile Materiel[1]	US Army Missile Command Redstone Arsenal, AL 35809
M	Weapons, Special Weapons, Chemical and Fire Control Materiel[1 2]	US Army Armament Materiel Readiness Command, Rock Island, IL 61299
P	Cryptologic Materiel	US Army Intelligence Command Vint Hill Farms Station Warrenton, VA 22186
Q	Electronics Materiel (DLA/GSA items).[1]	US Army Communications and Electronics Materiel Readiness Command, Directorate of Materiel Management, Fort Monmouth, NJ 07703
R	Bulk and Packaged Petroleum Fuels Packaged Petroleum Products, Containers and Accessories thereof, Certain Chemicals and Solid Fuels (DLA/GSA)[1]	US Army General Materiel and Petroleum Activity, New Cumberland, PA 17070
S	Subsistence (DLA/GSA items).[1]	US Army Support Activity Philadelphia, Philadelphia, PA 19101
T	Industrial Supplies (DLA/GSA items)[1]	US Army General Materiel and Petroleum Activity, New Cumberland, PA 17070
U	COMSEC Materiel	US Army COMSEC Logistics Agency, Fort Huachuca, AZ 85613

[1] Denotes secondary item materiel category titles.

[2] Does not include tracked vehicle repair parts which are managed under alpha code.

REFERENCES

1. Deemer, R. L. and W. K. Kruse, "Evaluation of Several VSL/EOQ Models", Final Report, US Army Materiel Systems Analysis Activity, Inventory Research Office, Philadelphia, PA, May 1974, AD-781948.

2. Faulhaber, Captain K. B., "Modification of Standard Base Supply System Stock Leveling Technique", Air Force Logistics Management Center, Gunter Air Force Base, Ala, December 1980.

3. Hutchison, A., "Calculations of Percent Error Tables for Use in the RIMSTOP", Technical Report, US Army Materiel Systems Analysis Activity, Inventory Research Office, Philadelphia, PA, September 1980, AD-A090141.

4. Kaplan, A. J., "A Note on Initial Fill Rate", Technical Report, US Army Materiel Systems Analysis Activity, Inventory Research Office, Philadelphia, PA, February 1980, AD-A080952.

5. Kruse, W. K., "Supply Performance Analyzer", Final Report, US Army Materiel Systems Analysis Activity, Inventory Research Office, Philadelphia, PA, June 1976, AD-A209711.

6. Office of Assistant Secretary of Defense Installation and Logistics, "Retail Inventory Management and Stockage Policy", four volumes, September 1976.

7. Orr, D. A., and A. J. Kaplan, "Economic Stockage Model", Final Report, US Army Materiel Systems Analysis Activity, Inventory Research Office, Philadelphia, PA, June 1971, AD-727694.

8. TM 38-L03-16, "Functional Users Manual for Standard Army Intermediate Level Supply Subsystem (SAILS) - Demand Analysis System", Headquarters, Department of the Army, April 1978.

9. TM 38-L32-2, "Detailed Functional System Requirement (DFSR) - Direct Support Unit Standard Supply System (DS4)", US Army Logistics Center, Fort Lee, VA, July 1976.

10. TM 38-L32-2-3, "Detailed Functional System Requirements (DFSR) - Direct Support Unit Standard Supply System (DS4)", Headquarters, Department of the Army, January 1981.

11. US Army Logistics Evaluation Agency, "Retail Inventory Cost Parameter Update Study (RICPUS)", New Cumberland, PA, November 1981.

Next page is blank.

DISTRIBUTION

COPIES	
1	Deputy Under Sec'y of the Army, ATTN: Office of Op Resch
1	Asst Sec'y of the Army (I,L&FM), Pentagon, Wash., DC 20310
	Headquarters, US Army Materiel Development & Readiness Command
1	DRCSM
1	DRCMS-E
1	DRCSM-WRS
1	DRCSM-PS
1	DRCSM-PAS
1	DRCIS-S
1	DRCMS
	Dep Chf of Staff for Logistics, Pentagon, Wash., DC 20310
2	DALO-SMP-U
1	DALO-SMZ-C
1	DALO-SMZ-A
1	Ofc, Asst Sec'y of Defense, ATTN: MRA&L-SR, Pentagon, Wash., DC 20310
1	Commandant, US Army Logistics Management Center, Ft. Lee, VA 23801
1	Defense Logistics Studies Info Exchange, DRXMC-D, ALMC, Ft. Lee, VA 23801
2	Defense Technical Info Center, Cameron Station, Alexandria, VA 22314
	Commander, USA Armament Materiel Readiness Cmd, Rock Island, IL 61299
1	DRSAR-SA
1	Commander, US Army Computer Systems Command Support Group, Ft. Lee, VA 23801
1	Commander, US Army Forces Cmd (ATTN: AFLG-MAS), Ft. McPherson, GA
	Commander, USA Communications-Electronics Cmd, Ft. Monmouth, NJ 07703
1	DRSEL-MM
	Commander, USA Missile Command, Redstone Arsenal, AL 35898
1	DRSMI-D
	Commander, USA Troop Support & Aviation Materiel Readiness Command, St. Louis, MO 63120
1	DRSTS-BA
	Commander, US Army Tank-Automotive Command, Warren, MI 48090
1	DRSTA-S
	Director, Army Materiel Systems Analysis Activity, APG, MD 21005
1	DRXSY-C
1	DRXSY-R
1	DRXSY-F
1	Commander, US Army Logistics Center, ATTN: ATCL-S, Ft. Lee, VA 23801
	Commander, US Army Logistics Evaluation Agency, New Cumberland Army Depot, New Cumberland, PA 17070
1	DALO-LER
1	DALO-LEP
1	Commander, US Army Depot Systems Command, Chambersburg, PA 17201
1	Commander, US Air Force Logistics Cmd, WPAFB, ATTN: AFLC/XRS, Dayton, Ohio 45433
1	US Navy Fleet Materiel Support Office, Naval Support Depot, Operations Analysis Department, Code 93, Mechanicsburg, PA 17055
1	Mr. James Prichard, Navy SEA Systems Cmd, ATTN: PMS 3061, Dept of US Navy, Wash., DC 20362
1	Air Force Institute of Technology, ATTN: SLGQ Head Quantitative Studies Dept., Dayton, OH 43433

1 US Army Military Academy, West Point, NY 10996

1 Commander, US Army Training & Doctrine Command, (ATPL-MD), Ft. Monroe, VA 23651

1 Commander, US Army Logistics Center, ATTN: Operations Analysis Directorate, Ft. Lee, VA 23801

1 Commander, US Army Logistics Center, ATTN: Concepts & Doctrine Directorate, Ft. Lee, VA 23801

1 Commander, West Com, Ft. Shafter, HI (APLG)

1 CINC USAREUR Heidelberg, Germany, ATTN: AEAGD-SM

1 Scientific Advisor, ATCL-SCA, Army Logistics Center, Ft. Lee, VA 23801

1 HQ, Dept of the Army, (DASG-HCL-P), Wash., DC 20314

1 Librarian, Logistics Mgt Inst., 4701 Sangamore Rd., Wash.,DC 20016

1 RAND Corp., ATTN: S. M. Drezner, 1700 Main St., Santa Monica, CA 90406

1 ALOG Magazine, ATTN: Tom Johnson, ALMC, Ft. Lee, VA 23801

1 Commander, USDRC Automated Logistics Mgt Systems Activity, P.O. Box 1578, St. Louis, MO 63188

2 Director, DARCOM Logistics Systems Support Agency, Letterkenny Army Depot, Chambersburg, PA 17201

1 Commander, Materiel Readiness Support Activity, Lexington, KY 40507

1 Director, Army Management Engineering Training Agency, Rock Island Arsenal, Rock Island, IL 61299

1 Defense Logistics Agcy, ATTN: DLA-LO, Cameron Sta, Alexandria, VA 22314

1 Dep Chf of Staff (I&L), HQ USMC-LMP-2, ATTN: LTC Sonneborn, Jr., Wash., DC 20380

1 Commander, US Army Depot Systems Command, Letterkenny Army Depot, ATTN: DRSDS-LL, Chambersburg, PA 17201

1 Logistics Control Activity, Presidio of San Francisco, CA 94120

1 Director, AMSAA, ATTN: Allen Hill, DRXSY-FLSO, Ft. Lee, VA 23801

1 Director, AMSAA, ATTN: Paul Arvis, DRXSY-PRO, Ft. Lee, VA 23801

1 Commander, US Army Communications Command, ATTN: CCD-SS-A, Ft. Huachuca, AZ 85613

1 COR, USA EIGHT (ATTN: DJ-SM), Seoul, Korea

1 DARCOM Intern Training Center, Red River Army Depot, Texarkana, Tx 75501

1 US Army Training & Doctrine Command, Ft. Monroe, VA 23651

1 Operations & Inventory Analysis Office, NAVSUP (Code 04A) Dept of Navy, Wash., DC 20376

1 US Army Research Office, ATTN: Robert Launer, Math. Div., P.O. Box 12211, Research Triangle Park, NC 27709

Air Force Logistics Mgt Center, Gunter Air Force Station, AL 36144

1 AFLMC/LGY

1 AFLMC/XRP, Bldg. 205

1 Engineer Studies Center, 6500 Brooks Lane, Wash., DC 20315

1 Commander, US Army Missile Cmd, ATTN: Ray Dotson, DRSMI-DS, Redstone Arsenal, AL 35898

1 Prof Barney Bissinger, The Pennsylvania State University, Middletown, PA 17057

1 Center for Naval Analyses, ATTN: Stan Horowitz, 2000 N. Beauregard St., Alexandria, VA 22311

8