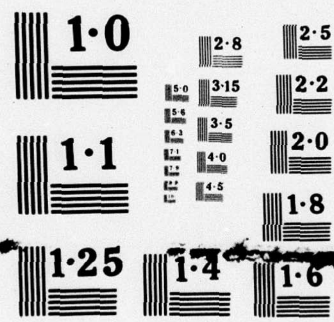
AD-A041 691 DRC INVENTORY RESEARCH OFFICE PHILADELPHIA PA F/G 15/5
FORECASTING ORDER AND SHIP TIME FOR CONUS DEPOTS.(U)
JUN 77 W K KRUSE

UNCLASSIFIED IRO-238 NL

1 OF 1
ADA
041691

END
DATE
FILMED
8-77



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

AD A041691

AD-
FINAL REPORT
IRO REPORT No. 238
(PHASE 1)

FORECASTING ORDER & SHIP TIME FOR CONUS DEPOTS

US ARMY
DARCOM

DRC
INVENTORY
RESEARCH
OFFICE

June 1977

ROOM 800
U.S. CUSTOM HOUSE
2nd and Chestnut Streets
Philadelphia Pa. 19106

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 U.S. Army Materiel Command unless so stated.

FORECASTING ORDER AND SHIP TIME FOR CONUS DEPOTS

FINAL REPORT

BY

W. KARL KRUSE

JUNE 1977

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DRC INVENTORY RESEARCH OFFICE
US ARMY LOGISTICS MANAGEMENT CENTER
ROOM 800 US CUSTOM HOUSE
2ND AND CHESTNUT STREETS
PHILADELPHIA, PA. 19106

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) FORECASTING ORDER AND SHIP TIME FOR CONUS DEPOTS.	5. TYPE OF REPORT & PERIOD COVERED FINAL REPORT,
	6. PERFORMING ORG. REPORT NUMBER on Phase 1
7. AUTHOR(s) W. KARL KRUSE	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS DRC Inventory Research Office, US Army Logistics Management Center, Room 800, US Custom House, Phila., 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 June 1977
	13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) IRO-238	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)

Active Army
ADP
Supply
Statistical
Forecasting

(cont fr p. 3)

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

Four techniques for forecasting OST at CONUS depots are evaluated against two years of OST history from New Cumberland Army Depot. Each technique uses either item history, catalog history, or both. Catalog histories are constructed by grouping items according to their DoD Item Manager and their Acquisition Advice Code.

Based upon the criterion of minimum root mean square forecast error, it was found that a technique which forecasts by groups of items rather than by

(cont on p1473B)

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

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

403572

Block 20 (cont)

individual item provides significant reduction to forecast error. Further improvements to this technique, although relatively small, are possible by allowing the individual item history to modify the pure group forecast.

SUMMARY

The technique currently used within SPEEDEX to forecast order and ship time, OST, not only has a questionable form, but also has never been empirically evaluated. The oddity of the technique is that it is based on the number of observations of OST during the previous 12 months, which is somewhat random, and not on a fixed number of observations as would a conventional statistical moving average. Moreover, since back-order time is included in the OST observations, it is quite possible for this technique to create significant forecast error on its own.

In this report, the current forecast technique, and three other techniques are evaluated against two years of OST history from New Cumberland Army Depot. The other three techniques require no data not currently available within SPEEDEX.

Based upon the criterion of minimum root mean square forecast error, it was found that a technique which forecasts by groups of items rather than by individual item provides significant reduction to forecast error. Further improvements to this technique, although relatively small, are possible by allowing the individual item history to modify the pure group forecast.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

1.1 Order and Ship Time

This report is concerned with the forecast of order and ship time, (OST) by CONUS depots. OST is the total elapsed time from the initiation of a request for an item by the Installation Supply Activity (ISA) until the item is received and recorded on the ISA stock accounts. The supplier of the item, in most cases, is a DoD Inventory Control Point, but may also be a commercial source or one of the depot's own manufacturing shops. →(cont on p 1473 A)

Forecasts of OST are used to determine when an item should be ordered. This may be through the development of a reorder point quantity which signals when assets reach a critical level, or the development of a time table of orders designed to have the stock on hand when it is anticipated to be needed. In either case, the forecasted OST value is a crucial determinant of the item's availability.

1.2 OST Process Variability

Table 1.1 shows the cumulative frequency distribution of OST for two groups of items used by New Cumberland Army Depot (NCAD).

The first group consists of all items on NCAD's stockage list as of March 75. The second group contains those items from group I which are DoD managed and stocked.

TABLE 1.1
Cumulative Frequency

OST Days	All Items	DoD Stocked
≤ 10	.14	.18
≤ 20	.42	.49
≤ 30	.70	.79
≤ 40	.82	.90
≤ 50	.88	.93
≤ 60	.90	.94
≤ 90	.94	.97
≤ 120	.96	.98

As expected, the DoD stocked items' OSTs are generally shorter than those for all items, but in both cases the distribution tail is long. For group I the variance to mean ratio is 13.01.

One interpretation of this distribution is that it is derived from a catalogue of items which experience constant OSTs for a given item, but which are different from item to item. The opposite interpretation is that each item's OST behaves randomly according to the relative frequencies indicated by the tabular distributions. The indications are that OSTs behave randomly by item, although not necessarily the same from item to item.

1.3 Present OST Forecast Technique

Within the SPEEDEX system today, the OST forecast for a given item is a simple average of the previous year's observation for that item. If there were no observations, the forecast is set to 30 days. Often with this procedure there are but one or two observations from which to forecast. Consequently, with the apparent large OST variability, it is not unreasonable to expect significant error in the forecast. Moreover, since the technique itself does not conform to any accepted statistical forecasting procedures, there is good reason to expect other, more conventional, techniques to perform better.

1.4 Group Forecast Technique

An inherent assumption of the present technique is that the OST process is significantly different from one item to another. Yet, for certain groups of items there is no a priori reason to expect a difference in the process.

At its most basic, the OST process is generated by the set of functions required to create, transmit, and process an order, to obtain and release stock, to transport and deliver the item, and to receive the order. The facilities which perform these functions naturally are used for many orders. For example, the MILSTRIP system processes all requisitions through a fixed network. Likewise only a few transport modes are used to ship the orders. Thus it seems possible, with the proper definition of groups, to use the group OST observations to forecast for a given item in that group.

Characteristics which should affect OST and which can be easily identified with SPEEDEX data files are the supplier or source of the item, and the DoD manager of the item. From data already available to the depots - the acquisition advice code and the item manager code - these characteristics are identifiable. The acquisition advice code identifies whether the item is stocked or not stocked by DoD managers, whether the item should be locally procured or manufactured, and whether the item is directly delivered from the manufacturer. The item manager code identifies the DoD item manager. AVSCOM, ECOM, DSA, and GSA are the managers for the majority of items used by NCAD.

Using two years of OST history from NCAD, items were classified as above and average OSTs produced within each class. These results are in Table 1.2.

Table 1.2

	AVSCOM	ECOM	DSA	GSA	OTHER
Stocked	26 (14661)	44 (884)	33 (15932)	51 (7970)	41 (7248)
Local Manuf.	-	-	-		-
Local Proc.	-	-	35 (98)		44 (43)
Dir. Delivery	-	103 (67)	78 (14)		-
Not Stocked	31 (157)	71 (13)	41 (178)		79 (87)
Other	34 (1078)	60 (17)	33 (1301)		39 (509)

The first number entered in the table is the average OST for the class, while the number in parenthesis is the number of observations of OST for all items in the class. Clearly there are obvious differences among the classes although some of the samples are small. Since our intent here is only to give credence to the hypothesis that there are differences, and since the ultimate test of this classification will come when evaluated as a forecast method, we did not perform a formal statistical analysis (i.e. ANOVA). The only conclusion we make now is that this classification has promise as a forecast mechanism.

1.5 Combination Technique

We have presented two views of the OST process. One, that it is completely item dependent, the other that it depends only on certain characteristics of items. And, we have demonstrated a classification scheme which appears to distinguish some significant characteristics.

Our evaluation procedure will not deal specifically with proving the correctness of these two viewpoints, but rather will rate them according to the performance of forecast methods based upon each viewpoint. With this empirical approach to evaluation, it behooves us to select other reasonable alternatives for testing as well.

We mentioned earlier that the two views are opposing. Yet, even if the group view is more correct, an average of individual item observations of OST should be a better forecast as the number of observations increases simply because the item itself has the characteristics which define the group. Consequently, we constructed a combination forecast which linearly combines the present and group techniques. The weight given to the present technique increases as the number of observations in the present technique increases.

1.6 Combination Technique With Truncated Observations

From time to time, the observed OSTs for any item will be unusually long if for no other reason than the supplier is temporarily out of stock. If OST history for a long period of time were available for each item, these long OSTs would be no problem. SPEEDEX, however, retains only one year of OST observations. Any long OST occurring by chance within the year may severely bias the forecast OST for an item. An adaptation of the combination technique was therefore developed in which the item average OST is truncated according to its deviation from the average OST of its group.

1.7 Inclusion of Backorder Delay in OST Observations

The SPEEDEX system, contrary to AR 710-2, has been collecting and using OST data with backorder delay included. Backorder delay is simply the time a request is held by the supplier awaiting stock to fill the request. In the previous section, we referred to the potential problem long backorder delays might cause in forecasting OST. In no way, were we being critical of including backorder delay in the OST observations.

While we were unable to empirically evaluate the inclusion of backorder delay since our data did not specifically breakout this from total OST, we nevertheless feel quite strongly that backorder delay should be included in the OST forecast. If we believe future supply support will continue near its present levels, then backorder delay is as real as the time to transport the item or any other element of the OST. It differs from the other elements only in the amount of randomness from one order to the next. For example, one request might experience no backorder delay, another 10 days of backorder delay, and still another maybe 60 days. But, this random variability only makes the forecasting of OST a difficult problem; it is not a reason for ignoring backorder delay.

CHAPTER II

COMPARISON OF ALTERNATIVES

2.1 Data Base

Two years of New Cumberland Army Depot OST history was obtained for all stockage list and some depot maintenance items. The data base was organized by NSN. From each item's data we used the acquisition advice code, the item manager code, and the 24 month summary of OST history which gave the total OST for orders delivered within the month along with the total number of orders delivered.

2.2 Alternative OST Forecast Techniques

As discussed previously, four basic forecast schemes were tested. In order to define them specifically, the following notation is introduced.

$OST_{i,n}$ = total OST for i^{th} item recorded in month n; n = 1,2,.........24

$N_{i,n}$ = total number of orders received for item i during month n

$F_{i,k,r}$ = forecast of OST made in month k for item i using technique r; r = 1,2,3,4

r = 1 represents the item average technique

r = 2 represents the group technique

r = 3 represents the combined technique

r = 4 represents the combined-truncated technique

BP_j = base period used in group technique for group j;

BP = 3 months for stocked items

= 12 for all other groups

(1) $$F_{i,k,1} = \sum_{n=k=13}^{k-1} OST_{i,n} / \sum_{n=k-13}^{k-1} N_{i,n}$$

(2) $$F_{i,k,2} = \sum_{i \text{ in } j^{th} \text{ group}} \; \sum_{n=k-BP_j-1}^{k-1} OST_{i,n} \Big/ \sum_{i \text{ in } j} \; \sum_{n=k-BP_j-1}^{k-1} N_{i,n}$$

(3) $$F_{i,k,3} = W_i F_{i,k,1} + (1-W_i) F_{i,k,2}; \qquad W_i = \frac{N_{i,k}^{[12]}}{m + N_{i,n}^{[12]}}$$

where

$$N_{i,k}^{[12]} = \sum_{n=k-13}^{k-1} N_{i,n}$$

m is a positive parameter which controls the effect $N_{i,k}^{[12]}$ on W_i. The smaller m, the more quickly W_i approaches 1 a $N_{i,k}^{[12]}$ increases.

(4) $$F_{i,k,4} = W_i F_{i,k,1}^T + (1-W_i) F_{i,k,2}$$

where

$$F_{i,k,1}^T = \min (F_{i,k,1}; F_{i,k,2} + B\tau)$$

τ = standard deviation of item OST averages about catalog average

B = truncation control parameter

Actually forms (1), (2), (3) are specific cases of form (4).

For example

(4) $\rightarrow$ (1) as $B \rightarrow \infty$ and $m \rightarrow 0$

(4) $\rightarrow$ (2) as $m \rightarrow \infty$

(4) $\rightarrow$ (3) as $B \rightarrow \infty$

2.3 Selection of a Base Period for the Group Technique

An unfortunate characteristic of the NCAD data was a significant decrease in OSTs, primarily within items managed and stocked by AVSCOM and DSA - the bulk of the items. For example, 12 month moving averages for AVSCOM stocked items went from 33.7 to 20 days, while DSA stocked items went from 35.2 to 20.8 days during the last 12 months of the two-year history. For the AVSCOM items, anyway, this seems to be the result of improving supply performance by AVSCOM, and the establishment within the two-year period of NCAD as the East Coast Supply Depot. The latter factor means that items formerly not stored by AVSCOM at NCAD are now stored there, thus eliminating a transportation lag from the OST.

We had hoped to determine the base period for the group technique by evaluating several base periods within the evaluation scheme. However, our data would clearly favor short base periods because of the trend. Random fluctuations or even short term trends in NICP supply performance are normal and should properly be allowed to affect the selection of a base period. On the contrary, management decisions like the establishment of NCAD as the supply depot follow no probabilistic laws and should not affect the decision on the base period.

Working under the assumption that NICP supply performance generates the primary random component of OST, we obtained six years of monthly stock availability statistics from DSA and performed analysis to determine the best moving average base period for prediction of the next month's availability. Since these statistics are aggregates of observations on many requisitions, the optimum base period from this should be a lower bound on the optimum base period for the group OST format. The rationale here is that the random variability in satisfying a requisition is what carries over to produce a corresponding variability in the OST.

A simple comparison of the mean squared error for several base periods indicated that a one-month base period was best for predicting the stock availability. While not as enlightening as we had hoped, nevertheless the results were insensitive to small changes in the base period. A three-month base period was selected for the group technique for stocked item groups. All other groups used a 12 month base period since the number of observations tended to be smaller than for stocked items.

2.4 Evaluation Technique

Error measures were produced for each alternative tested, by using the second year's history as the sequence of OST observations, and the appropriate earlier history to make the forecast. Specifically, if a single observation of OST was recorded in month n, $n > 12$, and the observation was x months, then it was taken that the forecast for that OST was made at the end of month $r = n - [x] - 1$ where $[x]$ is the integer part of x. The forecast was produced from the appropriate history preceding the end of month r and the error noted. For example, if $r = 15$ and the present technique is being used, then the average observed OST in months 4 through 15 is the forecast. All the available history is used in those cases where the full amount of history required by the forecast is not available.

The following error measures were collected.

$$\text{Root Mean Square Error} = \left(\sum_{i=1}^{N} (F_i - A_i)^2 / N\right)^{1/2}$$

$$\text{Bias} = \sum_{i=1}^{N} (F_i - A_i)/N$$

where

F_i = forecast for i^{th} observation

A_i = actual value of i^{th} observation

N = number of observations

where an observation is a specified item's OST for a specified month.

In early tests, other error measures were collected but provided no additional information. The above two were felt to be the most important.

2.5 Results

The RMSE for several forecast methods are shown in Table 2.1. The present technique is forecast form (1) from section 2.2 with the forecast set to 30 days when no observations are available.

TABLE 2.1

COMPARISON OF FORECAST TECHNIQUES

Forecast Technique	Truncation (Parameter (B)	Weighting Parameter (m)	RMSE
Present			41.9
Pure Group			38.28
Combined		3	38.0
		5	37.85
		7	37.82
		10	37.83
Combined-Truncated	1	3	37.62
	1	5	37.69
	1	8	37.78
	1.25	3	37.64
	2	3	37.72
	2	5	37.73
	2	8	37.79

Table 2.2 presents some additional information for the best of each of the four types of forecast methods.

TABLE 2.2

Forec. Class by Size of Forecast (days)	# Obs.	RMSE	Bias	Total $Error^2 \times 10^{-6}$
A. Present Technique				
< 22.5	3885	32.03	-4.24	1.885
22.5 - 37.5	6453	41.97	-5.01	11.366
37.5 - 52.5	1871	36.81	7.35	2.535
52.5 - 67.5	780	43.84	18.24	1.499
67.5 - 82.5	279	60.24	23.18	1.012
> 82.5	528	106.8	74.82	5.941
OVERALL	13796	41.9	1.82	24.239
B. Pure Group Technique				
< 22.5	2158	27.64	.2	1.648
22.5 - 37.5	6869	33.11	.2	7.530
37.5 - 52.5	3872	46.96	3.33	8.538
52.5 - 67.5	840	48.45	22.59	1.972
67.5 - 87.5	7	140.27	-68.43	.138
> 87.2	50	88.46	10.15	.391
OVERALL	13796	38.28	2.44	20.217

TABLE 2.2 (CONT)

Forec. Class by Size of Forecast (days)	# Obs.	RMSE	Bias	Total $Error^2 \times 10^{-6}$
C. Combined Technique (B =∞, m = 7)				
< 22.5	2258	20.63	2.54	.961
22.5 - 37.5	6915	31.23	1.03	6.744
37.5 - 52.5	3558	48.65	.65	8.421
52.5 - 67.5	848	55.54	13.32	2.616
67.5 - 87.5	126	52.21	29.30	.343
> 82.5	91	84.5	35.47	.650
OVERALL	13796	37.82	2.42	19.735
D. Combined-Truncated (B = 1, m = 3)				
< 22.5	2399	21.64	1.62	1.123
22.5 - 37.5	7081	31.47	.60	7.013
37.5 - 52.5	3355	48.57	.07	7.914
52.5 - 67.5	777	58.66	8.14	2.674
67.5 - 82.5	147	57.06	30.97	.478
> 82.5	37	93.10	20.84	.320
OVERALL	13796	37.62	1.45	19.523

If the present technique is considered a base case, and the others successive enhancements, then clearly the group technique contributes the most towards improvement (of RMSE). The following Table 2.3, which is a consolidation of Table 2.2 offers some insight to the source of improvement.

TABLE 2.3

Forecast Class.	# Obs.	RMSE	Total Error^2 x 10^{-6}
A. Present Technique			
≤ 52.5	12209	35.96	15.786
> 52.5	1587	72.98	8.453
B. Pure Group Technique			
≤ 52.5	12899	37.01	17.716
> 52.5	897	52.80	2.501
C. Combined Technique (B = , M = 7)			
≤ 52.5	12731	35.99	16.126
> 52.5	1065	58.21	3.519
D. Combined Truncated (B = 1, M = 3)			
≤ 52.5	12835	35.36	16.050
> 52.5	961	60.16	3.473

When forecasting the smaller OSTs, i.e., those under 52.5 days, the present technique does best. However, when forecasting larger OSTs, it is dramatically worse than the other three techniques. It seems, based upon the present technique's tendency to forecast larger values more frequently than the other techniques, that the one year average is too sensitive to long OSTs which occur by chance in the base period. Remember, this was the rationale behind the combined-truncated technique.

On the other hand, the group technique forecasts larger OSTs 53% less frequently (1587 vs 897), with a significant improvement to RMSE where it does so.

The combined and combined-truncated take advantage of the relative merits of the item average and group techniques, although with limited returns. The group technique improves upon the present technique by 16.6%, the combined technique improves the group technique by 2.4%, while the combined-truncated improves upon the combined technique by 1.1%.

The change in the best m parameter from the combined to the combined-truncated is also informative. When the item average is unconstrained, the m parameters must be larger to moderate the effect of the item average. Conversely, when the item average is truncated, it can be allowed to have a greater effect on the forecast. Table 2.4 shows the weights given to the item average in the best of the combined and combined-truncated techniques.

TABLE 2.4

# Observations in Item Average	Combined m = 7	Combined Truncated m = 3
1	.125	.25
2	.222	.40
3	.3	.50
4	.36	.57
5	.42	.625
6	.46	.666

2.6 OST Histogram

Table 2.5 is the histogram of observed OST by forecast class for the combined-truncated forecast method (B = 1, m = 3).

TABLE 2.5

OBSERVED OST / FOREC. CLASS	≤ 22.5	22.5 TO 37.5	37.5 TO 52.5	52.5 TO 67.5	67.5 TO 82.5	> 82.5	# OBS	AVG OST	BIAS
≤ 22.5	.854	.088	.026	.008	.004	.019	2399.	15.56	1.62
22.5 - 37.5	.518	.335	.058	.024	.018	.048	7081.	29.62	.60
37.5 - 52.5	.385	.274	.125	.060	.035	.120	3355.	44.12	.07
52.5 - 67.5	.347	.314	.103	.053	.040	.143	777.	49.49	8.14
67.5 - 82.5	.367	.381	.102	.027	.007	.116	147.	41.48	30.97
> 82.5	.243	.054	.135	.054	.108	.405	37.	92.62	20.84

While the overall bias is small, 1.45 days, (see Table 2.2D) compared to the overall average OST of 32.1 days, the bias by forecast class, in some cases, is quite large. Specifically for forecast categories greater than 52.5 days, the bias is large. Some evaluations had been made separating all DoD stocked items in one group, and all remaining items in another group. DoD stocked items seldom received OST forecasts greater than 52.5 days, and the other items which were mostly GSA items seldom received forecasts less than 37.5 days. Table 2.6 is a histogram of forecasts for GSA items alone.

TABLE 2.6

OBSERVED OST / FOREC. CLASS	22.5	≤ 22.5 TO 37.5	37.5 TO 52.5	52.5 TO 67.5	67.5 TO 82.5	82.5	# OBS	AVG OST	BIAS
≤ 22.5	-	-	-	-	-	-	0.		
22.5 - 37.5	.624	.232	.050	.022	.017	.055	181.	30.62	3.27
37.5 - 52.5	.411	.275	.104	.049	.028	.133	1442.	43.73	2.75
52.5 - 67.5	.373	.351	.101	.039	.030	.105	592.	43.20	14.24
67.5 - 82.5	.410	.402	.085	.009	.009	.085	117.	35.73	36.22
82.5	0.0	0.0	1.0	0.0	0.0	0.0	1.	29.00	43.83

Virtually all of the bias for forecasts over 52.5 days is due to GSA items. This seems to be due to a peculiarity during the second year of the OST history, where there was an unusual rise in OSTs for GSA items at the beginning, and a subsequent gradual return to the long run average towards the end.

In order to develop new reorder points and stockage criteria tables for CONUS depots, (a report on this work is being published shortly) a histogram of possible outcomes was required. Essentially, the histogram is used to compute the reorder point for given cost and control parameters, which in turn interacts with the stockage criteria determination. Since an unbiased histogram is required for this purpose, the bias for the recommended method (B = 1, m = 3) was removed from the histogram by subtracting out the average bias from each observation.

DISTRIBUTION

COPIES	
1	Deputy Under Sec'y of the Army, ATTN: Office of Op Resch
	Headquarters, US Army Materiel Development & Readiness Command
1	DRCMS
1	DRCDMR
1	DRCPS
1	DRCPS-S
1	DRCMM
1	DRCMM-R
1	DRCMM-RS
1	DRCMM-S
1	DRCMM-M
1	DRCMM-E
1	DRCRE
1	Dep Chf of Staff for Logistics, ATTN: DALO-SMS, Pentagon, Wash., DC 20310
2	Defense Logistics Studies Info Exchange, DRXMC-D
2	Commander, US Army Logistics Center, Ft. Lee, VA 23801
1	Commander, US Army Tank-Automotive Research & Development Cmd, ATTN: DRDTA-V, Warren, MI 48090
1	Commander, US Army Tank-Automotive Materiel Readiness Cmd, ATTN: DRSTA-S, Warren, MI 48090
1	Commander, US Armament Materiel Readiness Cmd, Rock Island, IL 61201
1	Commander, USA Electronics Command, Ft. Monmouth, NJ 07703
1	Commander, USA Missile Materiel Readiness Cmd, Redstone Arsenal, AL 35809
1	Commander, USA Troop Support Cmd, 4300 Goodfellow Blvd., St. Louis, MO 63120
1	Commander, USA Aviation Systems Cmd, P.O. Box 209, St. Louis, MO 63120
1	Commander, Army Automated Logistics Mgt Systems Agency, Box 14505, St. Louis, MO 63168
1	Director, DARCOM Logistics Systems Support Agency, Letterkenny Army Depot, Chambersburg, PA 17201
1	Commander, Maintenance Mgt Center, Lexington-Blue Grass Army Depot, Lexington, KY 40507
1	Director, Army Management Engineering Training Agency, Rock Island Arsenal, Rock Island, ILL 61202
1	Commandant, US Army Logistics Mgt Center, Ft. Lee, VA 23801
1	Defense Logistics Agency, Cameron Sta, Alexandria, VA 22314
4	Dep Chf of Staff (I&L), HQ USMC-LMP-2, ATTN: MAJ Sonneborn, Jr., Wash., DC 20380
10	Defense Documentation Center, Cameron Sta., Alexandria, VA
1	Commander, US Air Force Logistics Command, WPAFB, Dayton, Ohio, ATTN: AFLC/XRS 45433

COPIES	
1	US Navy Fleet Materiel Support Office, Naval Support Depot, Mechanicsburg, PA 17055
1	Mr. James Prichard, Navy Supply Systems Cmd, Dept of US Navy, Wash., DC
1	Naval Postgraduate School, ATTN: Dept of Opns Anal, Monterey, Calif 93940
1	Air Force Institute of Technology, ATTN: SLGQ, Head Quantitative Studies Dept., Dayton, Ohio 43433
2	The Army Library, Room 1A518, Pentagon, Wash., DC 20310
1	US Army Military Academy, West Point, NY
1	RAND Corp, ATTN: S.M. Drezner, 1700 Main St., Santa Monica, CA 90406
1	Office, Asst Sec'y of Defense (Inst & Logistics) ATTN: Mr. George Minter, Pentagon, Wash., DC 20310
1	US Army Materiel Systems Analysis Activity, ATTN: AMXSY-CL, Aberdeen Proving Ground, MD 21005
1	Commander, US Army Logistics Center, ATTN: Studies Analysis Div., Concepts & Doctrine Directorate, Ft. Lee, VA 23801
1	ALOG Magazine, ATTN: Tom Johnson, USALMC, Ft. Lee, VA 23801
1	Commander, US Army Depot Systems Command, Letterkenny Army Depot, Chambersburg, PA 17201
1	Logistics Control Activity, Presidio of San Francisco, CA 94120
1	Commander, Air Force Logistics Cmd, ATTN: AFLC/AQMLE, WPAFB, Dayton, Ohio 45433
1	HQ, Dept of the Army, (DASG-HCL-P), Washington, DC 20314
1	Mr. Ellwood Hurford, Scientific Advisor, Army Logistics Center, Ft. Lee, VA 23801
1	Logistics Studies Office, DRXMC-LSO, ALMC, Ft. Lee, VA 23801
1	Procurement Research Office, DRXMC-PRO, ALMC, Ft. Lee, VA 23801
1	Commander, US Army Aviation Systems Cmd, ATTN: DRSAV-D, P.O. Box 209, St. Louis, MO 63166
1	Commander, US Army Electronics Cmd, ATTN: DRSEL-SA, Ft. Monmouth, NJ 07703
1	Commander, US Army Armament Cmd, ATTN: DRSAR-SA, Rock Island, IL 61201
1	Commander, US Army Troop Support Command, ATTN: DRSTS-G, 4300 Goodfellow Blvd, St. Louis, MO 63120
1	Commander, US Army Mobility Equipment Research & Development Cmd, ATTN: DRXFB-O, Ft. Belvoir, VA 22060
1	Commander, US Army Natick Research & Development Cmd, ATTN: DRXNM-O, Natick, MA 01760
1	Commander, USA Missile R&D Cmd, ATTN: DRDMI-X-C, Redstone Ars, AL 35809
1	Commander, USA Missile R&D Cmd, ATTN: DRDMI-X-D, Redstone Ars, Al 35809