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COMPUTATIONS(U) NAVY FLEET MATERIAL SUPPORT OFFICE
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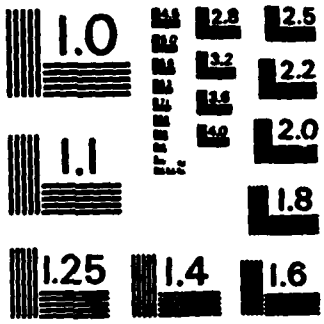

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EVALUATION OF AD/AR TENDER AND REPAIR SHIP LOAD LIST COMPUTATIONS

OPERATIONS ANALYSIS DEPARTMENT

NAVY FLEET MATERIAL SUPPORT OFFICE

Mechanicsburg, Pennsylvania 17055

Report 151

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EXECUTIVE SUMMARY

1. Background. The Tender and Repair Ship Load List (TARSLL) specifies the range and depth of the items carried by each destroyer tender (AD) and repair ship (AR). Separate load lists are prepared for the Atlantic and Pacific, but all ADs and ARs in the same ocean carry the same load. The current set of computations for AD/AR TARSLL was developed and approved by the Naval Supply Systems Command (COMNAVSUPSYSCOM) more than 15 years ago. Since then there have been numerous revisions, additions and deletions to the mathematical model, i.e., the computational rules. There has not been, however, any systematic evaluation of the model or of the AD/AR TARSLL production process during that time.

2. Approach. This study began by evaluating four alternative ways of extracting data to build the load list candidate file. Aspects of the model that were evaluated include the range, depth and protection level constraints, the Average Quarterly Demand (AQD) and risk of stockout computations, the effectiveness goal, and the use of separate effectiveness goals for different segments of the candidate file. The use of manual override quantities was also evaluated.

All test load lists were based on data extracted from the Navy Ships Parts Control Center (SPCC) files in 1979-1980. The demands used to build the load lists covered the period July 1977 through June 1979. The test loads were then evaluated by comparing the computed load list quantity with 90 days of subsequent actual tender demand. Evaluations were made for each type of tender for deployed and CONUS scenarios.

3. Findings and Recommendations. The candidate file analysis showed that large increases in the size of the candidate file produce large increases in

the size and cost of the load list but only small increases in effectiveness. Though the differences between the largest and smallest loads in terms of range (22,000 to 14,000 items) and cost ($3.7 million to $1.9 million) were significant, the differences in effectiveness never exceeded five percent and were often much smaller. The maximum gross effectiveness if all candidate items were stocked varied from 80-90% for all candidate files, indicating that most evaluation period demands were for candidate items.

The model evaluation indicated that elimination of the range cut would result in increased range and dollar value, but decreased effectiveness. This apparent paradox, more stock but less effectiveness, occurs because the lack of a range cut changes the mix of items on the load list. The items added do not satisfy as many demands as did the items deleted. Similarly, the study showed that the current criteria were more cost-effective than the other alternatives for computing AQD, computing stockout risk, setting minimum/maximum protection levels, and setting effectiveness goals.

This study also identifies several areas where changes will produce a more cost-effective load list. The basic change proposed is that the candidate file be divided into two segments; items which have experienced demand during the two year history used to build the candidate file should be separated from items which have not experienced demands. It is recommended that future AD/AR TARSLL loads be built with a lower range cut for demand-based items than for items with no historical demand. It is also recommended that all manual overrides for demand-based items be eliminated. While overrides for demand-based items did improve load list effectiveness when used with current procedures, they also raised the cost of the load list. The study, however, showed that the revised procedures recommended above, which utilize a lower

range cut for demand-based items, can reduce cost 500-700 thousand dollars for the same effectiveness or increase the number of requisitions satisfied as much as 11% for the same dollars, even if overrides are eliminated.

Finally, the study showed that current depth constraints on items with no historical demand tend to increase cost and decrease effectiveness. Items are constrained when high predicted usage is not reflected in the historical demand data. The items are also excluded from load list effectiveness calculations for the same reason. Such adjustments to the effectiveness computations produce changes in the stocking levels of many other items and here result in increased load list costs and lower load list effectiveness. Furthermore, depth constraints tend to decrease support for new weapons being introduced into the Fleet. Therefore, these constraints should be eliminated.

I. BACKGROUND AND INTRODUCTION

The Tender and Repair Ship Load List (TARSLL) specifies the range and depth of items carried by all ADs (Destroyer Tenders) and ARs (Repair Ships) in an ocean area to provide the required level of industrial support to the deployed Fleet for the first 30 days after mobilization without resupply. An AD/AR TARSLL is built by dividing the total area demand by the number of ADs and ARs in that ocean and then determining the range and depth of items needed to satisfy one tender's portion of the total demand. This range and depth of items becomes the load list for every AD and AR in that ocean area. The TARSLL is built from data contained in the Weapons System File (WSF) and the Mobile Logistic Support Force (MLSF) Demand History File (DHF) maintained by the Navy Ships Parts Control Center (SPCC). A mathematical model designed by the Navy Fleet Material Support Office (FMSO), which incorporates in its decision rules current Chief of Naval Operations (CNO) policy for the TARSLL, is used to develop the load list items and quantities of stock from the WSF data. It is this mathematical model which is the principal subject of this study.

The current model is the result of an evolutionary process begun more than 15 years ago when the original model logic was developed by FMSO and approved by Naval Supply Systems Command (NAVSUP) (then the Bureau of Supplies and Accounts). Since that time, an extensive number of changes have been made to the model by use of policy revisions, or as an attempt to correct a then current problem, or as a response to some special need of the Fleet, the supply system or elsewhere. For such, many times, only minimal analysis was made before a change was incorporated into the model, the overall effect on a given AD's or AR's load list performance or the cumulative

[illegible]

[illegible]

[illegible]

[illegible] cycle of [illegible]. [illegible]

[illegible]

F. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

as afloat IMA (method used for 1980 Atlantic AI/AK TARSIL) (called [illegible] in this report).

[illegible] procedure was used to extract data from the WSF for the same group of ships supported by the [illegible] Atlantic fleet AI/AK TARSIL. As TABLE 1 shows, the number of items produced by the two systems varied greatly.

TABLE 1

[illegible] FROM WSF

[illegible]	NUMBER OF ITEMS FROM WSF
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

[illegible] computer time for research projects became so [illegible] during the production of the five WSF [illegible] shown in TABLE 1. Therefore, when it was discovered that the IMI [illegible] were not [illegible] because of flawed data and duplicate records, the IMI [illegible] was [illegible] further delay to [illegible]. Fortunately, the IMI and WSF extracts are so similar that no [illegible] coverage should be lost because of this change to the original study [illegible].

[illegible] the four [illegible] the [illegible] IMI [illegible] [illegible] the [illegible] year period

from 1 July 1977 through 30 June 1979. The final composition of the four candidate files used in the study is shown in TABLE II.

TABLE II

TARSLL CANDIDATE FILE

SYSTEM USED TO SELECT APLs	NR ITEMS FROM WSF	NR ITEMS ONLY IN DMD FILE	TOTAL NR ITEMS IN CANDIDATE FILE
H1	304,705	12,407	317,112
H7	150,310	14,236	164,546
3M2	176,487	14,237	190,724
1980	117,450	18,981	136,431

It should be noted that the candidate file range is less than the sum of all items extracted from the WSF plus all items from the MLSF demand file. For example, in TABLE II, the H1 candidate file contains 317,112 items of which 304,705 are WSF items but only 12,407 of the 25,029 in the MLSF demand file are included in the candidate file count. This occurs because each separate National Item Identification Number (NIIN) on the WSF extract produces a corresponding record on the candidate tape, but only records unique to the demand file produce additional candidate records. If the same NIIN appears on both the WSF and MLSF demand extracts only a single candidate record containing data from both sources is built.

Each of the four candidate files listed in TABLE II was used with the current AD/AR TARSLL mathematical model program to build a test load list. The adjustable parameters in the model were set at the values selected during the production of the 1980 Atlantic AD/AR TARSLL. A list of the model's variable parameters and the settings used throughout this study are found in APPENDIX A. Using current model simulation procedures, each of the four test

loads was designed to have a predicted net requisition effectiveness of 90%. Range and price statistics for the test load lists built following these procedures are shown in TABLE III.

TABLE III

RANGE AND DOLLAR VALUE STATISTICS FOR ALTERNATE CANDIDATE FILES

CANDIDATE FILE	CANDIDATE RANGE	LOAD LIST RANGE	LOAD LIST COST (MILLIONS)
H1	317,112	22,023	$3.715
H7	164,546	18,711	2.859
3M2	190,724	18,187	2.353
1980	136,431	14,480	1.906

In order to evaluate these loads and the candidate files from which they are derived, it is necessary to measure the degree to which each load meets the performance goals it was built to achieve. The goal is the same for all four test loads. For a 90 day period, the load list should satisfy 90% of the requisitions for items carried on the load list without augmenting or resupplying the load list in any way.

The evaluation procedure consists of matching the load list against all the demands experienced by an actual AD or AR during a 90 day period and measuring the number of demands which the load list assets can satisfy. The demand used in the evaluation cannot be for the same time period as the demand used in developing the loads or the results will be biased.

The data used in the evaluation process for this study consist of demands for two different 90 day periods from each of two tenders, the USS VULCAN (AR 5) and the USS YOSEMITE (AD 19). The demands used to build the load lists

covered the period from 1 July 1977 to 30 June 1979. As TABLE IV shows, the demand used in the evaluations did not duplicate any of the load list demand.

TABLE IV

EVALUATION DEMAND DATA

TENDER	DEPLOYED OR CONUS DURING DEMAND PERIOD	TIME PERIOD
USS VULCAN (AR 5)	Deployed Med	1 Oct 79 to 31 Dec 79
USS VULCAN (AR 5)	CONUS	1 Mar 80 to 31 May 80
USS YOSEMITE (AD 19)	Deployed Med	1 Feb 80 to 30 Apr 80
USS YOSEMITE (AD 19)	CONUS	1 Jul 79 to 30 Sep 79

The evaluation program measures the effectiveness of each load list in terms of the number of NIINs satisfied, the number of requisitions satisfied, and the number of units satisfied. In each of these categories, the effectiveness is calculated in two different ways, net effectiveness - the percent of load list items demanded that are satisfied, and gross effectiveness - the percent of all demands that are satisfied.

Each of the four test loads described in TABLE III was matched against each of the four evaluation tapes. The results of these runs are shown in TABLE V.

It is noted that all effectiveness measures in this report reflect the ability of the load list quantity to satisfy 90 days of demand with no resupply and no consideration of additional Demand-Based Item (DBI) levels computed by the ship. A review of all Atlantic AD/AR ship supply effectiveness reports for 1980 indicates that actual gross requisition effectiveness generally varies between 55-70%, while net requisition effectiveness generally varies between

85-90%. The study effectiveness values were generally in the low 50s for gross and low 80s for net effectiveness.

TABLE V

EFFECTIVENESS RATIO OF TEST LOAD LISTS

CANDIDATE FILE USED TO BUILD LOAD LIST		USS VULCAN (AR 5) CONUS 3/1/80 TO 5/31/80			USS VULCAN (AR 5) DEPLOYED 10/1/79 TO 12/31/79			USS YOSEMITE (AD 19) CONUS 7/1/79 TO 9/30/79			USS YOSEMITE (AD 19) DEPLOYED 2/1/80 TO 4/30/80		
		NIINS	REQN	UNITS	NIINS	REQN	UNITS	NIINS	REQN	UNITS	NIINS	REQN	UNITS
H1 22,023 $3.715M	Gross	.578	.541	.575	.590	.559	.530	.693	.563	.444	[illegible]	[illegible]	.400
	Net	-	.856	.641	-	.841	.592	-	.733	.484	-	.913	.507
H7 18,711 $2.859M	Gross	.564	.526	.571	.577	.545	.527	.685	.554	.442	.555	.501	.456
	Net	-	.849	.642	-	.833	.561	-	.728	.484	-	.910	.575
DM2 18,187 $2.353M	Gross	.562	.522	.567	.574	.540	.522	.663	.550	.436	[illegible]	.494	.454
	Net	-	.845	.636	-	.830	.592	-	.724	.476	-	[illegible]	[illegible]
1980 14,480 $1.906M	Gross	.550	.512	.562	.557	.526	.518	.664	.532	.430	[illegible]	[illegible]	.466
	Net	-	.843	.634	-	.837	.593	-	.715	[illegible]	-	[illegible]	.585

When effectiveness is measured in terms of gross effectiveness (the percent of all demands that are satisfied) the AD load list has the highest effectiveness in each of the four evaluations and the 1980 load list has the lowest effectiveness. The greatest difference between them, however, is only 4.1% (57.2% NIIN effectiveness compared to 53.1% in the AD 19 deployed evaluation) and the 1980 load has compensating advantages over the AD load in that it only costs about half as much ($1.906 million compared to $3.715 million) and the 1980 range of 14,440 is within current Atlantic Fleet guidelines while the AD 22,023 item range exceeds them. The greatest difference between the gross requisition and units effectiveness values for the different candidate files was only 1.5% and 1.4%, respectively. The maximum differences in net effectiveness was 1.4%; however, this is a function of the parameter settings, not the candidate file.

As mentioned earlier, concern exists in the Fleet about the number of items on a load list which do not experience demands over long periods of time. TABLE VI shows the number of items on each test load which experienced no demand during each of the evaluation periods.

TABLE VI

NUMBER OF [illegible] EXPERIENCING NO DEMANDS DURING 90 DAY EVALUATION

[illegible] LOAD LIST	LOAD LIST RANGE	EVALUATION #1 [illegible] DEMANDS	EVALUATION #2 AD 5 DEPLOYED	EVALUATION #3 AD 19 DEMANDS	EVALUATION #4 AD 19 DEPLOYED
[illegible]	[illegible]	[illegible]	20,237	[illegible]	20,648
[illegible]	19,[illegible]	[illegible]	17,649	16,944	[illegible]
[illegible]	19,[illegible]	[illegible]	17,[illegible]	16,[illegible]	16,857
1980	13,[illegible]	[illegible]	13,454	[illegible]	13,204

In each case, only 1,000 to 1,800 items showed demand in any one quarter on a given tender. However, it is important to emphasize that current policy identifies the AD/AR TARSLL as war reserve stock. Thus, it is the ability to provide required intermediate level maintenance support in the period immediately after mobilization that determines how well the AD/AR TARSLL fulfills its mission. Since this study cannot directly measure the load list's response to wartime demands, instead it measured the load's ability to supply peacetime Fleet demands. Although only a small number of items experienced peacetime demand on a given tender in a given quarter, the load is largely an insurance level and it was not possible to measure how many items would be demanded across the entire Fleet under mobilization conditions. It is noted that a previous FMSO study (ALRAND Working Memorandum 358 of 3 June 1980) showed that AD/AR demands are very erratic with most items experiencing long intervals between demand. Over a seven year demand history in each Fleet, about 52% of the items experienced demand in only one of the seven years. Only 2,700 - 3,000 items in each Fleet experienced demand in each of the seven years. Furthermore, almost half the items demanded over the seven year period were unique to a single AD or AR. Thus it is not unexpected that a large portion of the load list range, which is built to support an entire Fleet over a three year period, would experience no demand on a given tender in a given quarter.

Since the TARLL V effectiveness is affected by the model range criteria as well as the candidate file, evaluations were carried one step further by mathematically computing the maximum possible effectiveness each candidate file can produce. This method has an advantage in that it is a direct measurement of the candidate file itself and not of a load list built from a

candidate file. This value is derived by adding the data on load list items experiencing demands to the data on nonload list candidate items experiencing demands and dividing by the total number of demands. The result is the maximum gross effectiveness that could be achieved by a candidate file during a given demand period if every candidate item was stocked. This value can be computed for NIINs, requisitions, or units.

The results of the maximum possible effectiveness computations appear on TABLE VII and show that the H1 candidate file has the highest maximum effectiveness in every category of all four evaluations. The 3M2 candidate file has the second highest effectiveness in eight of the 12 categories and either the H7 or 1980 files are always the least effective. While the H1 file contains more than twice as many candidate items as the 1980 load, the difference between them in terms of maximum NIIN or requisition effectiveness is never more than 5%. The difference in maximum units effectiveness is only 0.7% or less. For the 3M2 and 1980 files, the difference in maximum effectiveness is generally less than 1%. It is noted that the maximum gross effectiveness values are generally in the 80-90% range, indicating that most demands are for candidate items.

Clearly, the basic fact demonstrated in these tests is that the effectiveness of a candidate file and the load list built from it tends to increase as the number of items in the file or load list increases. If other things remain constant, large increases in the range of the candidate file will produce small increases in effectiveness but much larger increases in load list cost and range. The similarity of the TABLE VII values for each candidate file and the large difference between the TABLE V and TABLE VII values suggests that the model range criteria have a greater impact than the candidate file selection.

TABLE VII

MAXIMUM POSSIBLE EFFECTIVENESS

CANDIDATE FILE	CANDIDATE FILE RANGE	EVALUATION #1 - AR 5 CONUS 3/1/80 TO 5/31/80			EVALUATION #2 - AR 5 DEPLOYED 10/1/79 TO 12/31/79			EVALUATION #3 - AD 19 CONUS 7/1/79 TO 9/30/79			EVALUATION #4 - AD 19 DEPLOYED 2/1/80 TO 4/30/80		
		NIINs	REQNs	UNITs	NIINs	REQNs	UNITs	NIINs	REQNs	UNITs	NIINs	REQNs	UNITs
M1	317,112	.853	.876	.927	.906	.922	.936	.865	.905	.925	.784	.816	.826
M7	164,546	.781	.812	.914	.878	.900	.932	.845	.889	.921	.743	.780	.815
3M2	190,724	.813	.840	.920	.870	.895	.926	.849	.893	.923	.751	.788	.822
1980	136,431	.803	.835	.920	.863	.890	.929	.833	.882	.920	.739	.779	.826

III. TARSLL MATHEMATICAL MODEL

The AD/AR TARSLL model contains a group of mathematical routines that select the candidate items to be included in the load list, compute the appropriate depth for each load list item and measure the predicted effectiveness of the load list produced. This study examined the routines in the current model as well as possible changes or alternatives. Each routine examined is discussed separately in the following paragraphs.

A. RANGE CUT. The current AD/AR TARSLL uses a range selection procedure based on the total number of units demanded during a two year period. If historical demand is available, the total demand during the last two years is used. If no historical demand is available, the item's Next Replacement Factor (NRF) and population on the ships supported by the load are used to estimate the two year total demand. In selecting items for the load list, each candidate item's total demand is compared with a pre-selected value called the range cut point. All candidate items with a total demand greater than or equal to the range cut point are included in the load list. Those items falling the cut are excluded from the load list unless they have been assigned a mandatory or minimum override.

Manual overrides are assigned to items because of some special condition known to the authority assigning the override. There are four kinds of overrides - mandatory, maximum, minimum and exclusion. Overrides require that items have a specific depth (mandatory), a lower or higher depth (minimum) or no more than a specific depth (maximum). The exclusion override is used to keep a particular item off the load list. In short, items with mandatory and minimum override will be on the load even if they cannot

[illegible]

[illegible]

[illegible]

[illegible]

CANDIDATE FILE	RANGE CUT VALUE	RANGE	[illegible]
[illegible]	8	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]
[illegible]	8	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	8	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]
[illegible]	8	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]

As seen above for each candidate file, elimination of the range cut increased range by a multiple of four to seven and increased dollar value

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	TOTAL UNITS SATISFIED
None	[illegible]	[illegible]	[illegible]	42,568
[illegible] 50/[illegible]	[illegible]	[illegible]	[illegible]	41,19[illegible] -(3.3[illegible])
[illegible]	[illegible]	[illegible]	[illegible]	41,669 -(1.6%)

[illegible] increase [illegible] decrease units satisfied. [illegible] (11 requisitions) under the [illegible] effectiveness can increase as a result of the [illegible] items are excluded from the effectiveness projection. Thus, [illegible] may be required on other items to meet the same effectiveness goal. The decision to eliminate constrained items from [illegible] effectiveness simulation was based on the assumption that the demand [illegible] "[illegible]" of 18 predicted a 90 day requirement greater than one year passes, [illegible] the item experienced no fleet historical demand in two years. In general, the constraints do not improve the load list. [illegible] the request for new weapon being introduced [illegible] time to experience actual demand. [illegible] this will become a [illegible] The [illegible] will be [illegible].

[illegible] by computing [illegible] for each item. The [illegible] is used

later in the routines that compute load list depth and load list effectiveness. Two separate procedures can be used to compute the AQD. Each uses different data to make the computations.

The AQD can be computed as the simple average of historical demand or the AQD can be computed by multiplying the item's BRF by its population on the ships supported by the load list. The current model is designed to favor the computation based on historical demand. It will automatically select that option for any item with historical demand, even if the BRF and population data are also available. Only when an item has no demand history is the BRF times population procedure used.

A proposed new procedure for AQD computations is evaluated in this study. When historical demand data are available, the AQD is computed both with historical demands and with the BRF times supported population. The larger of the two values of AQD is used in the remaining model computations. The 3M2 candidate tape was used to evaluate the effect this and all future changes to the model would have on the load lists it produced. A demand and price profile of the 3M2 candidate file, based on the current AQD computation, is presented in APPENDIX B. The two load lists were built from the 3M2 candidate file. The first used the current 1980 AD/AR TARSLL model program without any changes. The second load was built using a model which contained the routine that selects the larger AQD. Both were built to provide 90% net requisition effectiveness. For this and all future tests, the evaluation was limited to the USS VULCAN (AR 5) demands during a CONUS assignment (March 1980 through May 1980). The results are shown in TABLE XI.

TABLE XI

IMPACT OF ALTERNATIVE AQD COMPUTATION

LOAD LIST MODEL	LL RANGE	LL COST (MILLIONS)	TOTAL REQNS SATISFIED	TOTAL UNITS SATISFIED
1980 AD/AR TARSLL	18,187	$2.328	1,269	42,588
"Larger AQD" Model	18,889 +(3.8%)	2.487 +(6.8%)	1,283 +(1.1%)	42,554 -(0.1%)

This evaluation demonstrates that the new "larger AQD" routine will satisfy about 1% (14) more requisitions but will also increase costs and slightly reduce the number of units satisfied.

D. RISK OF STOCKOUT. The current AD/AR TARSLL model computes a load list quantity by using a variable risk procedure. The model computes an acceptable risk of stockout for each item based on its unit price, average demand and essentiality.

$$\text{Risk} = \lambda \frac{\text{(Unit Price) (Average Requisition Size)}}{\text{(Essentiality)}}$$

where λ is a control parameter set to achieve the stated effectiveness goal. In the past, there have been no meaningful essentiality codes assigned. As a substitute for this lack of data, the AQD is currently used as a measure of essentiality when an item has experienced historical demand. If an item has no demand history, the "essentiality" for the item is developed in a special model routine using the item's population, its component to mission Military Essentiality Code (MEC) and its part to component MEC. A full description of the "essentiality" development routine is found in APPENDIX C. Use of the AQD as an "essentiality" measure tends to ensure that the faster

moving items receive high protection levels (low risk of stockout). After reviewing the current model program, SPCC recommended that the procedure for computing the "essentiality" for nondemand-based items be revised. SPCC requested that the AQD based on BRF times supported population be used as the "essentiality" for items with no demand history.

This proposed change to the current model was evaluated using the same technique described earlier. Two loads were built and then evaluated using actual tender demand. One load was built using the present model risk equation and associated procedures. The other load used a model containing the revised risk equation with AQD as a measure of "essentiality" for all items, as recommended by SPCC. Both loads were developed from the 3M2 candidate file and both were evaluated using the AR 5 (CONUS) demand file. The results are shown in TABLE XII.

TABLE XII

IMPACT OF REVISED "ESSENTIALITY" IN RISK FORMULA

RISK EQUATION	LL RANGE	LL COST (MILLIONS)	TOTAL REQNS SATISFIED	TOTAL UNITS SATISFIED
Current	18,187	$2.328	1,269	42,588
Revised	18,187	2.325 -(0.1%)	1,155 -(9.0%)	37,583 -(11.8%)

The use of the revised risk equation with AQD as the essentiality for all items caused large reductions in the performance of the load list in this evaluation. There is a current initiative to assign Mission Criticality Codes (MCCs) to all equipments installed on-board ships. Upon completion of this effort, it is anticipated that further study will be initiated to

incorporate these codes as the essentiality measure in the risk computation.

E. PROTECTION LEVEL CONSTRAINTS. Protection is the complement of risk, i.e., protection equals one minus risk. To compute the load list quantities on the AD/AR TARSLL, the mathematical model program computes a separate risk/protection for each item. While the value of risk/protection will vary from item to item, constraints applied to the computations prevent extreme or unacceptable values. These constraints, the maximum allowable risk and the minimum allowable risk, are adjustable and can be set at any value. It is also possible to set them at the same level, producing a fixed protection load in which all items have the same or a "fixed" risk/protection. Historically, the maximum and minimum constraints on risk have been set at 97.725% and 2.275%, resulting in minimum and maximum protection levels of 2.275% and 97.725%, respectively. These values have produced load lists that meet the required effectiveness goals while keeping costs as low as possible. These loads provide the highest support to low cost items with the highest rates of demand and only minimum support to higher priced items with lower rates of demand. This study examined the load list produced when the standard constraints on computed protection are changed. In particular, the study examined a load built using a 60% minimum protection instead of the usual 2.275% (40% maximum risk vice 97.725%). For this load, the constraint on maximum protection remained at 97.725%. These are the constraints currently proposed for the Fleet Issue Load List (FILL). The load with the revised minimum constraint was built and evaluated in the same manner described earlier in the study. The results are shown in TABLE XIII.

TABLE XIII

IMPACT OF 60% MINIMUM PROTECTION CONSTRAINT

PROTECTION LEVEL CONSTRAINTS	LL RANGE	LL COST (MILLIONS)	TOTAL REQN SATISFIED	TOTAL UNITS SATISFIED
MAX = 97.725 MIN = 2.275	18,187	$2.328	1,269	42,588
MAX = 97.725 MIN = 60.0	18,187	3.225 +(38.5%)	1,281 +(1.0%)	41,161 -(3.3%)

The evaluation showed that increasing the minimum protection constraint raises the cost of the load list and the increase can be significant. The change has much less effect on load list performance, but as the decrease in units effectiveness shows, the change does not improve the loads overall performance. The change also had no impact on the effectiveness for repairable items, possibly due to the low volume of demands (16) for repairables on the load list.

F. EFFECTIVENESS GOAL. Specific effectiveness goals have been assigned to the AD/AR TARSLL in the official instructions which control load list development. Currently, the goal is defined as the ability to satisfy 90% of the requisitions for load list items that are received during a 90 day period without any resupply. For this study, a load list was developed based upon a net units satisfied effectiveness goal rather than the present net requisition satisfied goal. To build this load list, a small revision had to be made to the risk equation in the load list math model program. When effectiveness is measured in terms of requisitions satisfied, the risk equation includes an item's unit price, essentiality and average requisition size.

$$\text{Risk} = (\lambda)\ \frac{(\text{Unit Price})\ (\text{Average Requisition Size})}{(\text{Essentiality})}$$

When effectiveness is measured in terms of units satisfied, the average requisition size is deleted from the risk equation.

$$\text{Risk} = (\lambda)\ \frac{(\text{Unit Price})}{(\text{Essentiality})}$$

In both equations, the "essentiality" is represented by either the item's AQD or by the relative item essentiality derived from the item's MEC (see APPENDIX C).

The load list built with a 90% net units satisfied effectiveness goal was evaluated using the standard procedures used throughout this project. The results are shown below in TABLE XIV.

TABLE XIV

IMPACT OF UNITS VS REQUISITIONS EFFECTIVENESS GOAL

EFFECTIVENESS GOAL	LOAD LIST RANGE	LL COST (MILLIONS)	TOTAL REQN SATISFIED	TOTAL UNITS SATISFIED
90% Net Requisitions Satisfied	18,187	$2.328	1,269	42,588
90% Net Units Satisfied	18,187	2.358 +(1.3%)	1,275 +(0.5%)	42,577 -(0.03%)

The evaluation results showed that the change from requisitions satisfied to units satisfied produced only a small increase in cost and almost no change in the effectiveness.

G. SIMULATION SEGMENTATION. In all the loads built thus far for this study, no differentiation has been made among the candidate items during the simula-

tion process. Historically, in building other types of load lists the candidate file has generally been broken into segments before the simulation process is begun. This is done by grouping together all items having some common characteristics not found in the other candidate items and applying the effectiveness goal to each separate category. A common procedure is to segment the candidates into Equipment-Related (ER) and Nonequipment-Related (NER) groups. For ER/NER items, a segmented simulation is used because the math model emphasizes cost effectiveness and tends to increase the depth of cheaper NER items at the expense of the depth for more costly ER items. Because of the range cut procedures currently used with the AD/AR TARSLL a segmented simulation process does not affect the range of the load list.

In this study, three different methods of dividing the candidate file were evaluated to determine if any of the procedures could improve load list effectiveness. The file was first divided into ER and NER segments, then into segments based upon each item's stores account, and finally into one group which had experienced historical demand and another group which had not. The ER/NER segments were evaluated first. Candidate items for the AD/AR TARSLL are defined to be ER if the item was contained in the WSF extract or if the item appeared in both the WSF and MLSF demand file extracts. Items which were only in the MLSF demand file extract are defined to be NER. (Since the WSF extract does not include all APLs on the supported ships, the ER/NER coding may be misleading.) Using the segmented simulation procedure, both the ER and NER items were simulated separately until each group had a predicted net requisition effectiveness of 90%. A total AD/AR TARSLL was computed by merging the results of the separate ER and NER simulations into a single load list. This merged ER/NER load was then

evaluated using the same procedures employed previously in this study. The second load built using a segmented simulation divided the candidate file into two parts based on the item's stores account code, which is the first character of the cognizance symbol. Items with a stores account code of 1, 3, 5 or 9 (consumables) were placed in one group, while those with 2, 4, 5, 7 or 8 (repairables) were placed in the other. Again, both groups were separately simulated to have a predicted net requisition effectiveness of 90%, then merged into a single load before the standard evaluation was accomplished. The final segmented simulation again divided the candidate file into two groups. One group contained all the items with one or more historical demands reported during the last two years. The other group contained all the items with no demands reported in the last two years. The same procedure was followed as with the other segmented loads. Both groups were simulated to the same 90% net requisition effectiveness, then merged into a single load which was evaluated using the standard procedures of this study.

TABLE XV contains the results from the evaluations of the three segmented load lists plus the data from a load built with no segmented simulation.

TABLE XV

IMPACT OF SEGMENTED SIMULATION

LL BUILDING PROCESS	LOAD LIST RANGE	LL COST (MILLIONS)	TOTAL REQN SATISFIED	TOTAL UNITS SATISFIED
No Segments	18,187	$2.328	1,[illegible]	4[illegible]
ER/NER Segments	18,187	2.373 +(1.9%)	1,[illegible] +(1.7%)	4[illegible] +([illegible].4%)
Stores Account Segments	18,187	2.370 +(1.8%)	1,[illegible] -(1.0%)	41,829 -(1.8%)
Demand/No Demand Segments	18,187	2.380 +(2.2%)	1,304 +([illegible].8%)	42,731 +(0.3%)

NOTE: All percentages use the No Segment load list as the base.

The evaluation results indicate that both the ER/NER and the Demand/No Demand segmented load lists outperform the nonsegmented load, but using a stores account segmented procedure reduces overall load list effectiveness. The ER/NER produces the largest increase in units satisfied while the demand/no demand load produces the highest requisition effectiveness. TABLE XVI shows a further breakdown of the segmented loads, showing the contribution each individual segment makes toward load list cost and effectiveness.

TABLE XVI

IMPACT OF EACH LOAD LIST SEGMENT

LOAD LIST	SEGMENT OF THE LOAD LIST	SEGMENT MAN [illegible]	SEGMENT COST (MILLIONS)	TOTAL [illegible]	TOTAL UNITS SATISFIED
ER/NER	ER	[illegible] (23.6%)	[illegible] ([illegible]%)	[illegible]	[illegible] (23.[illegible]%)
	NER	[illegible] (76.[illegible]%)	[illegible] ([illegible]%)	[illegible] ([illegible]%)	[illegible] (76.[illegible]%)
Demand/ No Demand	Demand	[illegible] (51.[illegible]%)	[illegible] ([illegible]%)	[illegible] ([illegible]%)	40,529 (98.[illegible]%)
	No Demand	[illegible] (48.[illegible]%)	[illegible] (47.[illegible]%)	[illegible] (1.[illegible]%)	[illegible] (0.[illegible]%)
Stores Account Code	[illegible] (Demandable)	[illegible] [illegible]	[illegible] ([illegible]%)	[illegible] ([illegible]%)	[illegible] (99.97%)
	[illegible] (Nonrepairable)	180 (0.0%)	[illegible] (10.[illegible]%)	12 (0.[illegible]%)	[illegible] (0.03%)

This table shows that less than 1% of the load list items and less than 1% of the demands were for repairables. Further analysis showed that there were only [illegible] demands for these items and only [illegible] of the [illegible] models satisfied 1% of them. Table XVI also shows that an important segment of the load list for production [illegible] items which have experienced [illegible]. [illegible] the "non-ER" segment [illegible] component [illegible] but [illegible] the requirements [illegible]. The "non-ER" segment [illegible] placed [illegible] the [illegible] items in the "Demand"

segment accounts for most of the demand. Statistical analysis was further conducted to determine the driving factor in computed demand [illegible]. This review indicated that items in the "demand" segment had [illegible] requisition effectiveness and [illegible] were quite effectiveness. Overrides had a major impact on achieving these effectiveness levels, as discussed in the next section.

IV. OVERRIDE ANALYSIS

For the [illegible] AD/AB [illegible], only minimum overrides were used. A minimum override assigns a specific load list quantity for a specific item. If the [illegible] math model computes a value larger than the minimum override quantity, the number computed by the math model is accepted. If, however, the computed quantity is less than the minimum override, the minimum quantity replaces the computed quantity and the override is said to be applied to the computations. TABLE XVII shows the number of minimum overrides applied in the Demand/No Demand segmented load list.

TABLE XVII

IMPACT OF MINIMUM QUANTITY OVERRIDES

	Items	Total Item Satisfied	Total Requs Satisfied	Total Units Satisfied
Total Load List (Segmented by Demand/No Demand)	10,197	1,083	1,308	82,731
Demand Items with Overrides	666 (3.7%)*	227 (21.0%)*	820 (32.7%)*	28,347 (66.3%)*
No Demand Items with Overrides	19	1	1	1

*Percent of total load list quantity.

[illegible]

[illegible]

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] shows that [illegible] reduces load [illegible] effectiveness ([illegible] fewer [illegible] and [illegible] [illegible]), but also cuts the cost of [illegible] [illegible] in the load [illegible] by [illegible]. Clearly, the reduced cost is desirable but the lower effectiveness is not.

Because removing the overpressure produced great changes in the load [illegible], the possibility existed that the overpressure could have affected the levels [illegible]. The results were [illegible] without overpressure to ensure that the original results had not been biased by the overpressure. While the absolute values in the results changed, the relationships between the various test levels remained almost constant and the conclusions derived from the original tests remained valid.

Because of the changes observed when the overpressures were removed, a series of test levels were built without overpressure using several different [illegible] models in an attempt to develop a procedure that would retain the lower cost of the load but raise the effectiveness back to the levels provided by the levels with overpressure. The first three of these new test levels utilized a model in which a "floor" or minimum value of protection

[illegible] protection for each item. The computed protection may be higher than the value selected for the "floor" but it cannot be lower. Table XIX shows the results from the evaluation of demand-based items on these three loads.

TABLE XIX

IMPACT OF ELIMINATING [illegible] AND RAISING MINIMUM PROTECTION LEVEL (DEMAND BASED ITEMS ONLY)

LOAD LIST	DEMAND-BASED ITEMS (NUMBER)	DEMAND ITEMS COST (MILLIONS)	NUMBER ITEMS SATISFIED	NUMBER UNITS SATISFIED
Least Cost with [illegible]	[illegible]	$1.245	1,129	40,[illegible]
Minimum Protection - 50% No [illegible]	[illegible]	.589	1,098	36,247
Minimum Protection - 80% No [illegible]	9,421	.764	1,087	35,974
Minimum Protection - 90% No [illegible]	9,421	.890	1,065	34,714

As Table XIX shows, the results of the tests were the exact opposite [illegible] effectiveness. [illegible] increase in the [illegible] requisition and unit effectiveness to [illegible] items [illegible].

The [illegible] tests of the extraction procedures indicated that increases [illegible] effectiveness. That procedure was tried [illegible] items could be [illegible] to increase [illegible] the load list

was increased by reducing the value of the range cut. Four test loads were built and evaluated. TABLE XX presents a comparison between the demand items on test loads built without overrides using the current and reduced range cuts and a load list built using overrides.

TABLE XX

IMPACT OF ELIMINATING OVERRIDES AND LOWERING RANGE CUT
(DEMAND-BASED ITEMS ONLY)

LOAD LIST	OVERRIDES USED	RANGE CUT POINT	RANGE OF DEMAND ITEMS	COST OF DEMAND ITEMS (MILLIONS)	TOTAL REQNS SATISFIED	TOTAL UNITS SATISFIED
1	Yes	8	9,436	$1.245	1,129	40,529
2	No	8	9,421	.477 -(61.7%)	1,099 -(2.7%)	36,281 -(10.5%)
3	No	4	12,122	.744 -(40.2%)	1,170 +(3.6%)	36,320 -(10.4%)
4	No	3	12,861	.897 -(28.0%)	1,195 +(5.9%)	36,335 -(10.4%)
5	No	2	14,569	1.243 -(0.2%)	1,234 +(9.3%)	36,353 -(10.3%)
6	No	1	17,013	2.057 +(65.2%)	1,292 +(14.4%)	36,395 -(10.2%)

The above table shows that it is possible to remove the overrides from the load list and, by also reducing the range cut point for demand-based items, produce a cheaper load with higher requisition effectiveness (see loads #3, 4, and 5). However, none of the test loads were able to match the unit effectiveness produced by the load list with overrides. Further analysis indicates that the 10% difference in the number of units satisfied is largely caused by overrides applied to four or five cheap, fast moving

items, and a single item accounts for about three-fourths of the 10% difference. These data are presented in TABLE XXI which shows the 20 demand items from the #4 load list which had the largest number of unsatisfied demands during the load list evaluation. The items are listed in order by the number of units not satisfied.

TABLE XXI

LOAD LIST #4 ITEMS WITH THE MOST NOT SATISFIED DEMANDS

ITEM NR	UNITS SHORT	UNITS DEMANDED DURING EVALUATION	MODEL COMPUTED L/L QUANTITY	UNIT PRICE $	COG	OVERRIDE QUANTITY
1	4,829	8,000	3,171	.02	9Z	0
2	3,149	9,600	6,451	.05	9G	46,287
3	1,676	1,800	124	1.45	9C	0
4	1,100	1,491	391	.18	9Z	0
5	1,000	1,000	*	*	*	0
6	980	980	*	*	*	0
7	896	900	4	.89	9C	0
8	618	1,100	482	.02	9Z	3,000
9	500	500	*	*	*	0
10	500	500	*	*	*	0
11	419	500	81	.86	1H	0
12	390	1,050	660	.16	9Z	7,511
13	366	409	43	3.01	9D	0
14	300	300	*	*	*	0
15	293	293	*	*	*	0
16	292	400	108	.38	9Z	831
17	258	500	242	1.13	9C	0
18	252	252	*	*	*	0
19	251	500	249	.68	1H	1,000
20	245	300	55	.05	9Z	0

*Items not in candidate or override file.

Along with the number of units short, the table also shows the number of units demanded during the evaluation and the load list quantity computed by the model. The difference between the units demanded and the load list quantity is the number of units short or not satisfied. If overrides had been used in this load list, items #2, 8, 12, 16, and 19 would have used

the override quantity instead of the quantity computed by the model. A comparison between the units demanded and the override quantity for these five items show that none of them would have had any unsatisfied demands in the load with overrides. TABLE XX shows that the demand items with overrides satisfied 40,529 units while the demand items from load list #4 without overrides satisfied only 36,335 items, a difference of 4,194 units. The difference in units satisfied for the five items shown above between the model computed depth and the override quantity is 4,700 units. This difference is enough to explain the improved units effectiveness produced when the overrides are used. Each of the five items is very inexpensive and has experienced high demand in the past.

The high units effectiveness and relatively high cost of the override items was examined further through the frequency distribution shown in TABLE XXII. The override quantity for each of the override items from load list #1 of TABLE XX is compared with the model computed quantity for the same item produced by load list #4 from the same table.

TABLE XXII

FREQUENCY DISTRIBUTION OF OVERRIDE QUANTITY VS COMPUTED LOAD LIST QUANTITY

LOAD LIST QUANTITY COMPUTED BY MODEL	OVERRIDE QUANTITY FOR SAME ITEMS											
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-80	81-100	101-1000	1001-9999	>9999
0		7	4	7	1	1	2	1	-	3	-	-
1		68	54	31	22	6	10	8	11	11	-	1
2		4	21	6	8	2	1	5	-	2	1	-
3		3	10	6	4	2	2	4	1	2	-	-
4		2	5	10	6	6	3	3	1	2	-	-
5		-	-	4	4	3	3	2	2	-	-	-
6		-	2	2	4	1	5	3	2	1	-	-
7		-	1	1	1	2	3	4	4	3	-	-
8		1	-	1	7	3	1	5	2	4	-	-
9		-	-	1	1	2	1	1	1	-	-	-
10-19		-	1	5	6	5	7	13	11	21	-	-
20-29		-	-	-	-	2	2	3	7	20	2	-
30-39		-	-	1	-	-	-	-	2	6	1	-
40-49		-	-	-	-	1	-	-	-	14	-	-
50-59		-	-	-	-	-	-	-	-	3	-	-
60-69		-	-	-	-	-	-	-	-	6	-	-
70-79		-	-	-	-	-	-	-	-	6	-	-
80-89		-	-	-	-	-	-	1	-	6	1	-
90-99		-	-	-	-	-	-	-	-	5	-	-
> 99		-	2	1	-	-	-	-	1	14	28	3
	0	85	100	76	64	36	40	53	45	129	34	4

The distribution data show the override quantity was generally significantly higher (often more than double) than the model computed quantity.

A small random sample of the override items was selected in order to make a comparison between the override quantity and the historical demand for the item. For every item in the sample shown in TABLE XXIII, the override quantity, which is theoretically supposed to satisfy 90 days of demand, is the equivalent of more than two years of demand for one tender. In one instance (see item 14) the override quantity represents more than 200 years of average demand. The data from this table and the earlier frequency distribution clearly indicate that the override quantity assigned to many items is excessive when compared to the expected demand for the item and causes an unnecessary expense.

TABLE XXIII also contains data from the AR 5 (CONUS) live data evaluation which shows that only three items from the sample were demanded during the evaluation period. For items #13 and 15, both the override and the computed quantity were sufficient to satisfy all the demands, but for item #1, the computed quantity could not fill all the units demanded. In summary, the overrides generally apply to historical demand items, the overrides do contribute to the effectiveness measures, but the override quantities are frequently excessive. A more cost effective approach would be to limit the overrides and expand the range of demand-based items.

TABLE XXIII

RANDOM SAMPLE OF OVERRIDE ITEMS COMPARED TO ACTUAL HISTORICAL DEMAND FOR THE ITEM

ITEM	UNIT PRICE	TOTAL ATLANTIC FLEET DEMAND (ONE YEAR) IN UNITS	AVG DEMAND IN ONE YEAR FOR EACH ATLANTIC AD/AR	OVERRIDE QTY FOR EACH TENDER	OVERRIDE QUANTITY IN TERMS OF YEARS OF SUPPLY (BASED ON ONE YEAR AVG TENDER DEMAND)	LOAD LIST QTY (90 DAY QTY) FOR ITEM COMPUTED BY TEST LOAD #3 (SEE TABLE XX)	UNITS DEMANDED DURING EVALUATION PERIOD
1	$14.45	138.5	23.07	107	4.64 Years of Supply	7	16
2	.83	30.0	5.00	27	5.40 Years of Supply	2	0
3	12.79	202.0	33.67	199	5.91 Years of Supply	10	0
4	.59	219.0	36.50	1,003	27.48 Years of Supply	23	0
5	4.42	85.0	14.17	53	3.74 Years of Supply	9	0
6	26.21	61.0	10.17	29	2.85 Years of Supply	1	0
7	58.58	30.0	5.00	21	4.2 Years of Supply	1	0
8	29.84	1.5	0.25	8	32.0 Years of Supply	0	0
9	3.32	32.0	5.34	22	4.12 Years of Supply	1	0
10	3.95	15.0	2.50	10	4.0 Years of Supply	1	0
11	.79	79.5	13.25	71	5.36 Years of Supply	7	0
12	3.32	16.0	2.67	11	4.13 Years of Supply	1	0
13	.02	530.0	88.33	463	5.24 Years of Supply	66	9
14	32.24	.5	0.09	20	235.29 Years of Supply	0	0
15	.08	73,847.0	12,307.92	25,978	2.11 Years of Supply	4,328	3,725

V. RELATED STUDIES

Before the study described in this report was completed, a study was released by the Naval Postgraduate School (NAVPGSCOL) which also analyzed the AD/AR TARSLL math model. The study is entitled "An Analysis of the 1977 AD/AR TARSLL" of September 1980 and was prepared by Lieutenant Commander James Hargrove, Jr. Efforts were made in this FMSO study to avoid unnecessary repetition of the studies described in that report. There are duplications, however, because portions of the analysis had been completed before the NAVPGSCOL report was received and reviewed. Areas included in the NAVPGSCOL study that were not covered by this FMSO study include the use of frequency distributions other than the Normal distribution to represent demands, and the effects of time on load list performance. The NAVPGSCOL study analyzed both the Poisson and Gamma distributions as substitutes for the Normal distribution currently used in the AD/AR TARSLL math model. The study found that the load lists built with the Poisson and the Gamma distributions had lower effectiveness than the load built with a Normal distribution, and recommended continued use of the Normal distribution. The study also reported on the results of a test which measured the changes in load list effectiveness that occur over time. The study found that overall effectiveness declined less than 5% over a two year period. Based on this and the stability of the demand data, the study found that creation of a new load list every three years is adequate.

Two areas included in the NAVPGSCOL report were also examined during the FMSO study. These areas are the use of the AQD as a measure of essentiality for all items, and the removal of the range cut from the math

model. The most important factor about these studies is that the reports disagree. In evaluating the use of the AQD as a measure of essentiality for all items, the NAVPGSCOL study found that this model change produced a "modest" increase in cost, an increase in effectiveness of less than one-half percent and, therefore, recommended that the change be used in the future. This FMSO study of the same subject found a slight reduction in cost, from $2.328 million to $2.325 million, and a large decrease in both the number of requisitions satisfied (9.0%) and in the number of units satisfied (11.8%) (see TABLE XII). Because of these findings, this study recommends that this model change not be used.

Deleting the range cut from the math model was also studied in both projects and again each study had different results. During the NAVPGSCOL study, the removal of the range cut increased the range from 13,217 to 19,975, cut the cost of the load list about in half and increased effectiveness less than 3%. Further investigation was recommended because of the low cost. The NAVPGSCOL study also evaluated reducing the range cut to a value of 4.0, but recommended against this change. In this FMSO study, removing the range cut increased the range for the 1980 load list from 14,480 to 65,886, increased the load list cost from $1.906 million to $6.459 million (see TABLE VIII), reduced the number of requisitions satisfied by 10.8% and reduced the number of units satisfied by 4.3% (see AR 5 (CONUS) evaluation in TABLE IX).

It is believed that the differences between the two studies is caused by a combination of the different data used in the two studies and the different procedures employed. The NAVPGSCOL study used 1977 data as compared to 1980 data in this study. In building a test load list to compare with the basic load list, the NAVPGSCOL study changed only the math model program itself.

All parameters, including the Lagrange multiplier in the risk equation (1) remained at the same value meaning that any differences between the two load lists had to be caused by the differences in the math models. In this study, not only were the math models changed, but the Lagrange multiplier in the risk equation (1) was adjusted until both the test load and the benchmark load had a predicted net requisition effectiveness of 90%.

A further point should be made about the FMSO evaluation of the zero range cut model. Removing the range cut caused the mix of items on the load to change. With the range cut, the 14,440 items on the load list included 9,301 items with historical demands. Without the range cut, the 6[illegible],[illegible]86 items included only 4,[illegible]1 items with historical demands. As shown earlier, the items with historical demands provide the majority of the units and requisitions satisfied and it is their removal from the load list that causes the effectiveness to decline in the load list built without a range cut. It is interesting to note that the statistics provided in APPENDIX A and APPENDIX [illegible] of the NAVMISSO study indicate that the same decrease in demand-based items occurred in that study between the benchmark load list and the no range cut load list though it is a less dramatic change than in the FMSO study. In the NAVMISSO study, 7,[illegible]7 demand-based items are included in the 13,217 of the benchmark load list, but there are only 4,[illegible]3 demand-based items included among the 11,215 items of the no range cut load. As a final word of explanation, the removal of the range cut also removes from the math model the routine which "forces" all items that pass the range cut on to the load list. Here, "forces" means that even if the math model computes a zero load list quantity for an item which passes the range cut, the routine will "force" a load list quantity of one unit for the item to ensure it takes place on the load

list. Apparently, many demand-based items which can pass the range cut will not compute to a load list depth and do not make the load list without the "forced quantity" routine.

VI. CONCLUSIONS AND RECOMMENDATIONS

This study has reviewed the present AD/AR production system and has identified areas where changes can be made that will produce a more cost-effective load list. Several specific changes to current procedures are recommended. Each change has increased load list effectiveness, reduced load list costs or both in the tests made during this project. The basic change proposed is that the candidate file be divided into two segments before simulation procedures begin. In particular, it is recommended that items which have experienced demand during the two year history used to build the candidate file be separated from other items which have not experienced such demands. Each group of items can then be simulated separately.

The study showed that demand-based items, those items that have experienced demands in the past, provide the majority of units and requisitions satisfied during the load list evaluations. It also showed that increasing the range of demand-based items on the load, by reducing the range cut for demand-based items, improved effectiveness even further. It is recommended, therefore, that future AD/AR TARSTA loads be built with a lower range cut for demand-based items than for items with no historical demand. This change can cause the load list range to exceed the 14,000 item range now used for the AD/AR TARSTA; however, the increased effectiveness and lower cost of the load should compensate for any increased workload generated during ship.

Since policy concerning the range of the TARSTA can change, and the com-

[illegible]

[illegible]

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[illegible]

[illegible]

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It is further recommended that all manual overrides for demand-based items be eliminated. While overrides for demand-based items did improve fill rate effectiveness when used with current procedures, they also raised the cost of the fill rate. The study, however, showed that the revised procedures recommended above, which utilize a lower range cut for demand-based items, can produce cost savings higher than manual fill rate and increase the number of requisitions satisfied even if overrides are eliminated. The old procedure with overrides does satisfy more of the units demanded, but the study showed that the extra units satisfied only represent very high demands for several cheap items, such with a unit price of less than one dollar. It cannot be cost-effective to expend several hundred thousand dollars for overrides if that is the sole benefit that is achieved. It must also be remembered that the revised procedures do assign a fill rate quantity to these sub items, though it is smaller than the override quantity, and that the Sailor's SUMMS (Shipboard Uniform Automated Data Processing System) procedures will provide additional stocks for all demand-based items when the ship requires it.

APPENDIX A: AD/AR TARSIL MAIN MODEL PROGRAM PARAMETERS

The mathematical routines included in the AD/AR TARSIL model program have been made as flexible as possible so that they can be used in various situations without requiring recoding for new values. This flexibility is achieved by using variable parameters [illegible] the program instead of constant values. There are also places in the program where two or more different routines are available to compute the same parameter. In computing the AOD, for example, the program provides one routine that uses historical demand and another that uses the item's MTBF and supported population to make the calculations. Because of these variable parameters and multiple routines, the user must initialize the program before it can be used. This is done by assigning a specific value to the variable parameters and selecting the appropriate routine for each computation when more than one is available.

A deck of cards, called parameter cards, are used to enter the required data into the program. A complete description of these cards and how they are prepared and used can be found in the User's Manual for the "Uniform Inventory Control Program Computation of TARSIL Range and Depth" which is AMCP Pamphlet Number [illegible] of 21 May 1979.

Some of the TARSIL model program variable parameters are included in mathematical routines that are used every time the program is run. It is mandatory that the user assign values to these parameters. The remaining variable parameters are in optional program routines and are assigned values only when the routines are used in the TARSIL computations.

[illegible] variable parameters and optional program routines [illegible] below along with

[illegible] each parameter. All the [illegible] followed by the optional parameters. [illegible] used during the [illegible] that follow. Information about [illegible] Manual described earlier.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

and replace the item. The K2 parameter is found in the routine which uses BRF and item population to compute AQD.

$$AQD = \frac{BRF}{4} [(POPS)(K2) + (POPT)(K3)]$$

A value of 0.1 was assigned to K2 throughout this study.

5. K3 - this value represents that portion of an item's "tender population" (POPT) that is supported by the tender. "Tender Population" is defined as the item population that is used in applications requiring intermediate (tender) level maintenance capabilities to remove and replace the item. The K3 parameter is used to compute AQD (see description of K2 parameter). A value of 0.67 was assigned to K3 throughout this study.

6. Essentiality Computation Parameters - (see APPENDIX C for definitions). The following values were assigned to the essentiality parameters throughout this study:

$$KF = 1.00$$

$$KS = 0.67$$

$$KT = 1.00$$

$$ALPHA_S = 0.12$$

$$ALPHA_T = 0.12$$

The following optional parameters were also used during the course of this study:

1. The [illegible] adjustment factor - the AQD computed for each item by the [illegible] model program represents the total quarterly demand for an entire [illegible]. Since the [illegible] program is computing the load list quantities for a single [illegible] or tender ship, mean AQD must be adjusted to represent the AQD for just one tender. This adjustment is made by multiplying

the ocean AQD by the adjustment factor, X2. Since there are six Atlantic ADs and ARs, the value of X2 in this project becomes:

$$X2 = 1/6 = 0.166 = 0.17$$

The value of X2 was set at 0.17 throughout this project.

. KMAX and KMIN - the routine which computes an acceptable risk of stockout for each item contains variable parameters which define the maximum and minimum allowed values of computed risk/protection. The program is designed to automatically use a maximum allowed risk (KMAX) of 0.97725 and a minimum allowed risk (KMIN) of 0.02275 unless other values are entered by the program user. In this study, the built-in value of 0.02275 for minimum risk (equivalent to a maximum protection of 0.97725) was used throughout the study. However, the built-in value of 0.97725 for maximum risk was adjusted at several points during this project. When changes were made, they are clearly described in the body of the report and at all other times the built-in value was used.

As noted earlier, the TARSLL program provides several different routines for making some calculations and also allows the user to exclude routines that are not needed. This study made use of both of these options at appropriate times. When, for example, the range cut procedures were not wanted or required, the program was instructed by the use of the appropriate parameter card, to skip the range cut routine. Similarly, when tests of a load list based on units satisfied were made, a parameter card was used to instruct the program to use the units effectiveness computations in place of the normal requisition effectiveness routine.

APPENDIX B: DEMAND/PRICE DISTRIBUTION

UNIT PRICE (X)	ATLANTIC FLEET QUARTERLY DEMAND (Y)					TOTAL
	$Y \leq 10$	$10 < Y \leq 100$	$100 < Y \leq 500$	$500 < Y \leq 1000$	$Y > 1000$	
$X \leq 1$	6.85%	5.15%	3.59%	1.25%	4.09%	20.93%
$1 < X \leq 50$	19.78%	14.77%	8.37%	2.28%	4.78%	49.98%
$50 < X \leq 100$	3.24%	2.17%	1.09%	.26%	.36%	7.12%
$100 < X \leq 500$	5.71%	4.24%	1.90%	.37%	.37%	12.59%
$500 < X \leq 1000$	1.69%	1.35%	.51%	.07%	.06%	3.68%
$1000 < X \leq 5000$	2.06%	1.54%	.53%	.08%	.03%	4.24%
$X > 5000$	.80%	.48%	.15%	.02%	.01%	1.46%
TOTAL	40.13%	29.70%	16.14%	4.33%	9.70%	100.00%

APPENDIX C: COMPUTING RELATIVE ITEM ESSENTIALITY

The current AD/AR math model program uses the procedures described below to compute a numeric value for Relative Item Essentiality ("E") for those items with no demand history. The value computed for "E" is used in computing the item's acceptable risk of stockout. The computation of "E" uses the following item data:

POPS - (DEN E28) - item population on supported ships requiring only organizational (ship) level maintenance capability to remove and replace it.

POPT - (DEN E28A) - item population on supported ships requiring intermediate (tender) level maintenance capability to remove and replace it.

MECS - (DEN E26) - a pseudo average Military Essentiality Code, developed in UICP program E17CZ. It is considered the average MEC for the item population requiring organizational level maintenance.

MECT - (DEN E26A) - a pseudo average MEC developed in UICP program E17CZ. It is considered the average MEC for item population requiring intermediate level maintenance.

The computation of "E" also uses the following variable parameters (see APPENDIX A).

KE - Standard Item Essentiality (DEN V216) - the value assigned to "E" if it cannot be computed because of missing data.

KS = Fleet Essentiality Coefficient - (DEN V217) - a weighting factor assigned to the computation of "E_{ij}". "E_{ij}" is the value of

"E" computed for the item population requiring organizational level maintenance.

KT = Tender Essentiality Coefficient (Den V219) - a weighting factor assigned to the computation of "E_T". "E_T" is the value of "E" computed for the item population requiring intermediate level maintenance.

$ALPHA_S$ = Fleet Essentiality Exponent (DEN V218) - the parameter used to control range of values that can be computed for "E_S" (see above). By adjusting the value of $ALPHA_S$, the difference between the highest "E_S", computed for the most essential organizational level items, and the lowest "E_S", computed for the least essential organizational level items, can be changed. Currently $ALPHA_S$ is set so that "E_S" varies between 1.0 (highest essentiality) and 0.001 (lowest essentiality).

$ALPHA_T$ = Tender Essentiality Exponent (DEN V220) - used for same purpose as $ALPHA_S$, but is applied to "E_T" computations. "E_T" also ranges from 1.0 to 0.001.

The value of "E" is then computed using the following three formulae:

$$E_S = (KS)e^{-(116 - MECS)\,ALPHA_S}$$

$$E_T = (KT)e^{-(58 - MECT)\,ALPHA_T}$$

$$E = \frac{(POPS)E_S + (POPT)E_T}{POPS + POPT}$$

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13. ABSTRACT

This study evaluated alternative procedures for the [illegible] AD/AR Tender and Repair Ship Load List [illegible]. Included in the study are the evaluation of four different procedures for data extraction from the Weapon [illegible], some possible changes to the current [illegible] model program, and the [illegible] of some manual overrides [illegible]. Based on the findings from the study, [illegible] be used in the [illegible] computation [illegible] available, [illegible] items with demand history [illegible] without demand history [illegible], that [illegible] lower range [illegible] for items with [illegible] demand [illegible] for other items, and that [illegible] applied [illegible] items [illegible]. It [illegible] the potential to improve total [illegible] current [illegible]

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