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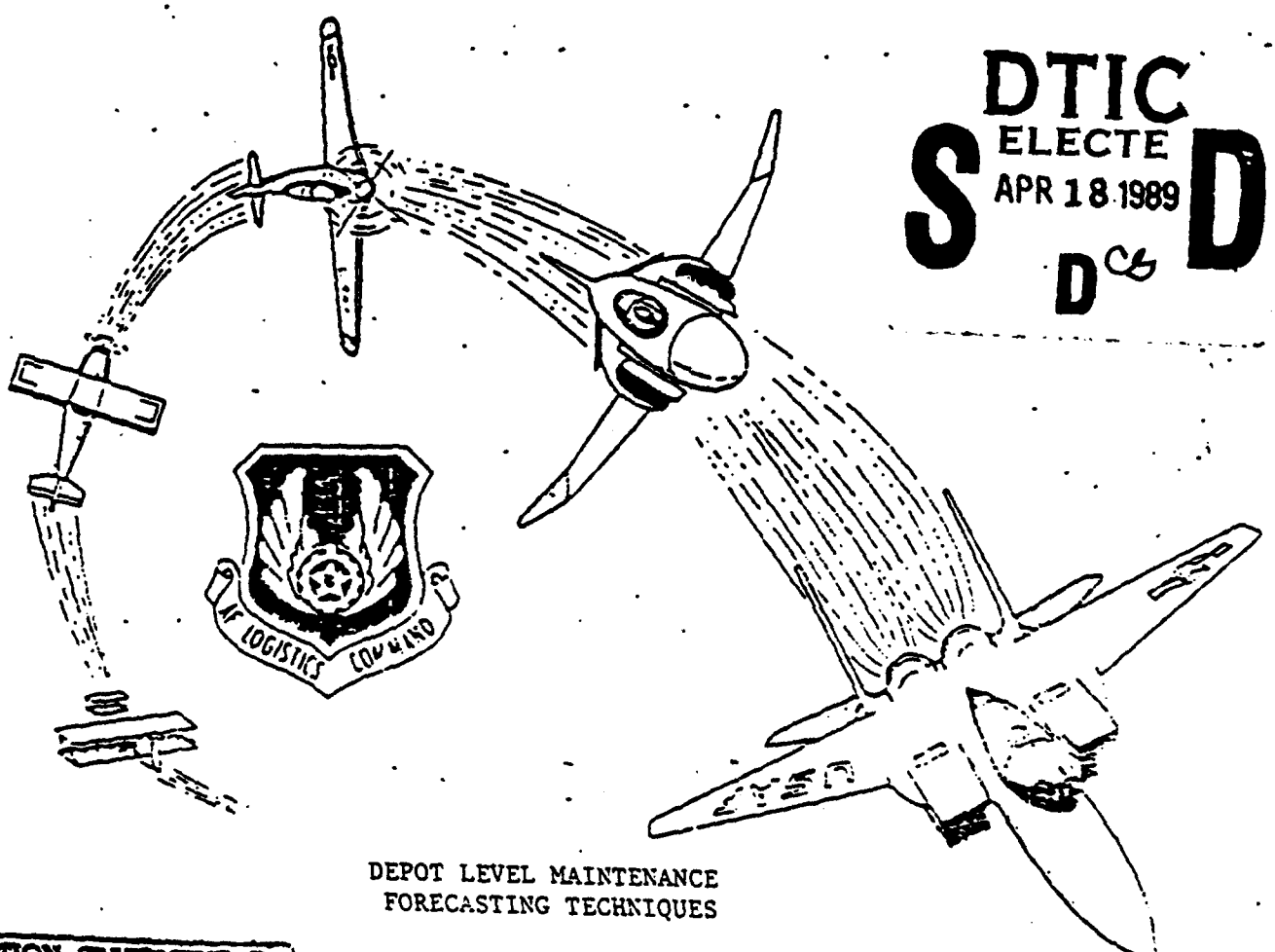

DEPOT LEVEL MAINTENANCE
FORECASTING TECHNIQUES

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MR MARK GAETANO

HQ AFLC/MMMA
JANUARY 1989

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LOGISTICS COMMAND
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(1)

REPLY TO ATTN OF: MMMA

21 MAR 1989

SUBJECT: Depot Level Maintenance Forecasting Techniques

TO: See Distribution

1. The Economic Order Quantity (EOQ) Buy Budget Computation System (D062) has two different techniques to forecast requirements for consumable items to support Depot Level Maintenance (DLM). One method uses past depot demand history while the other uses future end-item DLM program projections. Many item managers question the validity of future end-item DLM program projections and therefore almost always use past depot demand as a forecast. We need to determine which of these two methods is better for forecasting actual demand for consumable DLM items.

2. We compared the two forecasting techniques using actual consumable data. We found that the forecasts based on end-item DLM programs and replacement percents are highly inaccurate. The method based on past depot demand history provided a much better forecast for predicting consumable DLM requirements. However, this forecasting technique is still inaccurate. We recommend investigating the accuracy of the end-item repair data and the replacement rates being passed to D062. In addition, we recommend investigating other techniques that can be used to forecast consumable requirements to support depot level maintenance.

3. Our conlusions and actions are provided at Attachment 1. Points of contact are Bill Morgan or Mark Gaetano, HQ AFLC/MMMA, AUTOVON 787-5270.

FOR THE COMMANDER

GERALD G. ELLMYER, Lt Col, USAF
Ch, Analysis & Information Mgt Div
DCS/Materiel Management

2 Atch
1. Conslusions and Actions
2. Final Report

CONCLUSIONS AND ACTIONS

CONCLUSIONS

1. The Economic Order Quantity (EOQ) Buy Computation System (D062) uses two methods to compute consumables requirements to support depot level maintenance (DLM): past demand history or future end item DLM projections.

2. The DLM projections computed in D062 from the Master Materiel Support Record (D049) and the Depot Level Maintenance, Requirements, and Program Management System (G072E) are inaccurate.

3. Item managers use the DLM projections only about one percent of the time and instead use past history to forecast consumable requirements for DLM.

4. Past depot demand history provides a more accurate forecast than the end-item DLM program projections.

5. Item managers are generally selecting the best forecast.

6. We found no systematic way to automatically select the best forecasting technique.

7. The current acquisition advice code used for identifying items used exclusively for depot level maintenance is inaccurate.

ACTIONS

1. Investigate the accuracy of replacement rates and end item repair data passed to D062 from both D049 and G072E. (OPR: MMMA, OCR: MMME, MMMR)

2. Continue to default to using past history (type 'B' computation) in D062. (OPR: MMME)

3. Allow item managers to continue selecting the appropriate computations to use on a per item basis. (OPR: MMME)

4. Investigate alternative techniques for forecasting consumable requirements to support DLM. (OPR: MMMA, OCR: MMME, MMMR)

5. Clean up the acquisition advice code, especially the code used to identify items used strictly for depot level maintenance. Introduce a new code to identify all items used in support of depot level maintenance. (OPR: MMME)

ABSTRACT

The Economic Order Quantity (EOQ) Buy Budget Computation System (D062) includes two techniques to forecast EOQ parts needed to support depot level maintenance (DLM). One method uses future end-item DLM program projections and the other uses past depot demand history. This report discusses the current D062 requirements algorithm and the accuracy of each forecasting method. We also discuss the validity of the acquisition advice code to identify consumable items used to support depot level maintenance.

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CHAPTER 1

THE PROBLEM

Item managers seldom use the future depot level maintenance (DLM) projections developed by the Economic Order Quantity (EOQ) Buy Budget Computation System (D062) to determine EOQ requirements for DLM. Most item managers use past actual depot demand history to forecast future consumable requirements to support DLM. In many cases the repair projections from the Master Materiel Support Record (D049) and the Depot Level Maintenance, Requirements, and Program Management System (G072E) overforecast actual demand. In such cases, using the future DLM end-item program projections causes item managers to purchase many unneeded EOQ assets which then stratify as inapplicable inventory. This results in less money available to buy other needed assets. We need to determine which of D062's two methods is better for forecasting actual demand for consumable DLM items.

OBJECTIVES

1. Determine whether past history or DLM programs are more accurate to project consumable requirements for DLM.

2. Determine the source of inaccuracies in the DLM program projections and how to improve the projections.

BACKGROUND

DLM consumable items are used by depot maintenance during routine repair major overhauls and similar activities. The Economic Order Quantity (EOQ) Buy Budget Computation System (D062) uses two techniques to forecast requirements for consumable items to support Depot Level Maintenance (DLM). One method of forecasting uses past actual depot demand history from the Depot Supply Account (D033). The other forecasting method uses future end-item DLM program projections computed by the D062 system from inputs provided by the Master Material Support Record (D049) and the Depot Level Maintenance, Requirements, and Program Management System (G072E). The item manager has the option to choose either method for each item. In most cases, the item managers use the past demand history from D033 to forecast consumables needed to support DLM programs. Accurate forecasts allows D062 to buy the right parts at the right time to support depot maintenance programs. Inaccurate forecasts result in buys of unneeded assets or shortages of critical repair parts. So, we need to look at the accuracy of today's systems.

CHAPTER 2

CURRENT ECONOMIC ORDER QUANTITY (EOQ) BUY BUDGET COMPUTATION SYSTEM (D062)

OVERVIEW

This chapter overviews the D062 system and explains in detail the two computations used in forecasting consumable requirements to support Depot Level Maintenance (DLM). We explain how these two computations work internally within the D062 system and how they interface with other systems.

CURRENT SYSTEM

Currently, the D062 system has three methods for computing overall buy requirements. Each method uses a different algorithm and is distinguished by the 'type computation code', a file maintained code which identifies a particular algorithm to the D062 system. Table 2-1 shows the three types of computations.[1]

TYPE COMPUTATION CODE

CODE	DESCRIPTION
A	USED IN SUPPORT OF DEPOT LEVEL MAINTENANCE
B	USED FOR MOST EOQ ITEMS
C	USED FOR INSURANCE AND OTHER DIFFERENT EOQ ITEMS

Table 2-1

The type 'A' computation is specifically designed to compute buy requirements for consumable items used to support DLM. The type 'B' computation computes requirements for base support, and in some cases, depot support. The type 'B' computation is used for most EOQ items. The type 'C' computation is used for special cases, such as insurance, contingency, and new items.

It is up to the item manager to choose the appropriate type computation code for each item. If the item manager chooses not to file maintain a type computation code, the system will automatically default to a type computation code 'B'. If the use of an item changes, the IM can file maintain the proper type computation code. In the next three sections, we explain in detail these three different types of requirements computations.

TYPE 'A' COMPUTATION

This computation is designed for consumables which support Depot Level Maintenance (DLM). In this case, D062 uses future end-item DLM program projections, two years of past demand (excluding depot and contract demands), and quantitative requirements. D062 computes future DLM requirements using input from two other systems. Quarterly end item repair requirements come from the Depot Level Maintenance, Requirements, and Program Management System (G072E). The second source is the Master Material Support Record (D049), which provides the quantity per application (QPA) and the replacement percentage rate for each consumable used on the repair of the end item. If a match occurs between the G072E system and D062 application record, D062 uses the repair program quantity contained in G072E and replacement data in D049 to compute the DLM requirement for the type 'A' computation. The DLM part of the requirement is computed as follows:

DLM REQT = REPLACEMENT RATE X QPA X PROGRAM QTY

The total D062 requirement is the sum of the two year moving average of past demand history for non-depot and non-contract demands, the DLM requirements (computed above) and any quantitative requirements. The D062 system uses this demand rate to compute the economic order quantity (EOQ), which is the amount of stock to order and the reorder level (ROL), which identifies when the order should be placed.

TYPE 'B' COMPUTATION

This method uses two years of all past net demands (including depot and contract demands) plus quantitative requirements. The past depot sales are passed from the Depot Supply Account (D033). The D062 system uses the demand history to compute an average demand rate (MDR). The MDR is then used in computing the EOQ and ROL.

TYPE 'C' COMPUTATION

D062 uses the type 'C' computation for items with known requirements but no past demands or future end item repair programs. These items include new items and those with shelf life and short program life. Also included are insurance and contingency items. Known requirements are generally unprogrammed workloads that past demand history would not cover. The requirements for these items are based on projected quantitative requirements only. Quantitative requirements are projections of requirements by quarter for three years into the future. The item manager is responsible for file maintaining quantitative requirements.

For computation codes 'A' and 'B', D062 includes quantitative requirements in addition to past demand. A 'C' computation uses quantitative requirements only.

SUMMARY

The type A computation considers the end-item future DLM program to project consumable requirements to support DLM. The type B computation uses only past history. With accurate data, the type A computation should be more proactive to future repair program requirements. Yet, most item managers use past history (type B computation) to project consumable requirements for DLM. The next chapter compares the accuracy of each computation method.

CHAPTER 3

ANALYSIS

OVERVIEW

In this chapter, we describe our analysis of the two D062 demand forecasting techniques to compute consumable requirements to support DLM. We discuss our analysis in four parts. We first describe our database, then we overview our analysis approach. We segmented our data two ways, so we discuss results separately for each segment.

DATA BACKGROUND

We used four years (1983-1987) of consumable requirements data from Ogden ALC. We used the first two years as a baseline, and then used the third and fourth year to see how well each forecasting method performed. We used all the items with a four year history. Our entire data base had over 72,000 items.

APPROACH

We first determined how often item managers actually used each of the two techniques. Both methods are available to the item manager to predict these requirements. It is up to the item manager to select which method he/she thinks is more appropriate. Examining the first two years of our database, we found the item managers used future DLM requirements projections for 750 items (only one percent of the time). They used D033 past depot demand history for 67,355 items (94 percent), and quantitative requirements for the remaining items.

Which method of forecasting DLM consumable requirements is better? **Most item managers seem to have little faith in the projections, illustrated by the fact that only one percent of all items used DLM program projections.** We decided to compare the accuracy of the two techniques to highlight any problems with the repair program and bill of materiel projections being passed from the Depot Level Maintenance, Requirements, and Program Management System (G072E) and the Master Material Support Record (D049).

Originally, we tried to divide our database using the acquisition advice code. This code is used to identify the general category of purchasers of an item. But, we found many instances where the item usage and its code were inconsistent, causing us to question the validity of the code. Many items that were coded as restricted requisition - major overhaul, which we assumed as an item used to support DLM, had conflicting types of demands.

Appendix A discusses the acquisition advice code and our findings. As an alternative to using the acquisition advice code, we divided our database into two groups of items. The first group of items included all those that had non-zero DLM requirements projections, regardless of whether or not the item manager actually used these projections (type 'A' computation). These were items which D049 and G072E said were required for end-item repair programs. This first group excluded all the items which had zero DLM projections. The second group included all the items which actually used DLM projections (type 'A' computation) regardless of whether or not the DLM projections were zero. In fact, most of these items (72 percent) had zero DLM projections, but the item manager chose to use the zero projections to forecast DLM requirements anyhow. By selecting these two groups of items, we knew either the current systems or the item managers identified the item as one used in support of depot level maintenance

GROUP 1: ITEMS WITH DLM PROJECTIONS

This group totalled 6,754 items and included any item which had a nonzero projected DLM requirement regardless of whether or not the item manager actually used the projected requirement. These items are obviously candidates to use DLM projections as a forecast. Out of this total, item managers used these projections for only 209 items (three percent). The remaining 97 percent used past depot and contract demand history and ignored the DLM projections to forecast the DLM consumables requirement.

We analyzed the first group of items using three different methods. The first method computed the DLM forecast using two years of DLM requirements projections, and simulated a type 'A' computation. The second method used two years of past depot and contract sales, and simulated the type 'B' computation. The third method took the larger of the previous two methods and used that quantity to forecast the DLM requirement. This method is similar to the way D033 stocks parts: it uses the larger of historical demand or projected data from the Bill of Material.

For each method, we used the first two years of data to project the second two years. We then determined the number of correct forecasts and the dollar value over/under forecast relative to the actual DLM requirements. Table 3-1 shows the results.

COMPARISON OF FORECAST ACCURACY
(NUMBER OF ITEMS AND DOLLAR VALUE OF THE DIFFERENCE)

	CORRECT FORECAST	UNDER FORECAST		OVER FORECAST	
	ITEMS	ITEMS	DOLLARS SHORT	ITEMS	DOLLARS EXCESS
DLM PROJECTIONS	305	3,237	$22.6M	3,212	$24.4M
PAST HISTORY	1,801	1,974	$ 9.8M	2,979	$14.6M
LARGER OF THE TWO	640	1,404	$ 7.8M	4,710	$35.6M

Table 3-1

The total cost of actual DLM requirements over the second two years (1985-1987) was $44.5 million for this group of 6,754 stock numbers. Table 3-1 shows the DLM projection (Type 'A') was correct for only 305 items. We define 'correct' as those forecasts which were within ten percent of actual demand. The type 'A' method underforecasted $22.6M across 3,237 items. In addition, this method overforecasted $24.4M across 3,212 items.

Theoretically, item managers should use the DLM projections for the items with DLM requirements, provided G072E and D049 are working properly. Table 3-1 shows the consumable requirements developed from DLM projections are highly inaccurate.

The second method (Type 'B') used forecasts based on past demands. This method predicted 1,801 items correctly. This number is much higher than the number correctly predicted by the first method. Many of the correctly forecasted items (nearly 25 percent) were inactive items -- they experienced no demand during the two year period. Using past history correctly predicted these inactive items two out of every three times, where the type 'A' approach failed to predict any of these items correctly. Using past history also underforecasted $9.8M across 1,974 items and overforecasted $14.6M across 2,979 items.

Table 3-1 shows the third method, using the larger of the DLM forecast or past history, clearly overforecasts most of the time.

We next computed an "optimal" forecast. When both methods either overforecasted or underforecasted, we chose the forecast closest to the actual demand. Where one method overforecast and the other underforecast, we felt it was better to overforecast, up to the point where the difference was two times that of the underforecast. As an example, if the actual demands for the period were ten and the two forecasts were six and sixteen, the forecast of sixteen would be the "optimal" forecast. This "optimal" forecast is not something we could implement in D062 because it

requires knowing the answer in advance of the forecast. However, the "optimal" forecast gives us a benchmark and represents the "best" the item manager can do within the confines of the current system. Table 3-2 shows the results.

'OPTIMAL' FORECAST COMPARISON
(NUMBER OF ITEMS AND DOLLAR VALUE OF THE DIFFERENCE)

	CORRECT FORECAST	UNDER FORECAST		OVER FORECAST	
	ITEMS	ITEMS	DOLLARS SHORT	ITEMS	DOLLARS EXCESS
OPTIMAL FORECAST	2,067	2,079	$ 9.1M	2,608	$ 7.6M
ACTUAL FORECAST USED BY THE ITEM MANAGER	1,712	2,008	$10.0M	3,034	$14.5M

Table 3-2

Note that the "optimal" forecast is indeed better than any of the forecasts in Table 3-1. Table 3-2 shows little difference between the item managers choice versus the "optimal", except the item managers tend to overforecast. However, the item managers are doing a better job than using past history or DLM projections alone. It appears the item managers are doing a good job in deciding which forecast to use, given the available techniques. As we pointed out earlier, item managers selected past history nearly 97% of the time. If the item managers used past history only, they would have decreased their underforecasted dollars (from $10M to $9.8M), but would have also increased overforecasted dollars (from $14.5M to $14.6M).

Projections using future DLM program requirements would have been the best forecast for only 12 percent of the items. Identifying these items apart from the other 88 percent is extremely difficult. We tried to determine if any item characteristics could be used to determine which forecasting technique to use. We performed several statistical tests, such as an analysis of variance, but found no reliable method for automatically selecting the most accurate forecasting technique. Though we found no systematic way for an item manager to know when to use a particular forecast, using past history generally provides a better result than the current DLM program projections.

GROUP 2: ITEMS USING DLM PROJECTIONS

In this section, we discuss the analysis of our second group of items. This group consisted of all items where the item managers actually used DLM projections in their requirements computations.

In many cases item managers selected the DLM projection even though the DLM projection was zero.

This group has 750 stock numbers, of which 541 (72 percent) have DLM projections of zero. We performed the same type of analysis as we performed on the first group. Table 3-3 shows the results.

COMPARISON OF FORECAST ACCURACY
(NUMBER OF ITEMS AND DOLLAR VALUE OF THE DIFFERENCE)

	CORRECT FORECAST	UNDER FORECAST		OVER FORECAST	
	ITEMS	ITEMS	DOLLARS SHORT	ITEMS	DOLLARS EXCESS
DLM PROJECTIONS	477	145	$995K	128	$439K
PAST HISTORY	531	74	$483K	145	$658K
LARGER OF THE TWO	456	59	$455K	235	$964K
OPTIMAL FORECAST	583	79	$482K	88	$257K

Table 3-3

Though the item managers actually used DLM projections in their requirements computations for these items, Table 3-3 shows these projections are not very accurate. Item managers actually used these projections which came in $995K dollars and 11,352 units short of actual demand, which was 21,210 units totalling $1.5 million dollars. Only about 100 of the items were better off using the DLM projections. Past history provides a better overall forecast by correctly predicting more items and reducing the number of items underforecasted.

As a group, these 750 items would have been better off using past history. Analysis on these items again show no characteristics which could be used to automatically select the best forecasting technique.

SUMMARY

The consumable DLM requirements projections are inaccurate. Past depot demand history provides a more accurate forecast than the projections being passed from D049 and G072E. We recommend D062 continue to default to using past history (type 'B' computation). We need to investigate the accuracy of the replacement rates and end item repair data being passed to D062. In addition, we plan to study other forecasting techniques, such as exponential smoothing.

Our analysis shows item managers are doing a good job selecting the most accurate technique to determine EOQ requirements for DLM. We recommend this continue until more accurate forecasting techniques and more reliable methods for selecting the most accurate technique are developed.

CHAPTER 4

CONCLUSIONS AND ACTIONS

CONCLUSIONS

1. The Economic Order Quantity (EOQ) Buy Computation System (D062) uses two methods to compute consumables requirements to support depot level maintenance (DLM): past demand history or future end item DLM projections.

2. The DLM projections computed in D062 from the Master Materiel Support Record (D049) and the Depot Level Maintenance, Requirements, and Program Management System (G072E) are inaccurate.

3. Item managers use the DLM projections only about one percent of the time and instead use past history to forecast consumable requirements for DLM.

4. Past depot demand history provides a more accurate forecast than the end-item DLM program projections.

5. Item managers are generally selecting the best forecast.

6. We found no systematic way to automatically select the best forecasting technique.

7. The current acquisition advice code used for identifying items used exclusively for depot level maintenance is inaccurate 10 to 20 percent of the time.

ACTIONS

1. Investigate the accuracy of replacement rates and end item repair data passed to D062 from both D049 and G072E. (OPR: MMMA, OCR: MMME, MMMR)

2. Continue to default to using past history (type 'B' computation) in D062. (OPR: MMME)

3. Allow item managers to continue selecting the appropriate computations to use on a per item basis. (OPR: MMME)

4. Investigate alternative techniques for forecasting consumable requirements to support DLM. (OPR: MMMA, OCR: MMME, MMMR)

5. Review the acquisition advice code, especially the code used to identify items used strictly for depot level maintenance. (OPR: MMME)

APPENDIX A

ACQUISITION ADVICE CODE

APPENDIX A

ACQUISITION ADVICE CODE

OVERVIEW

The acquisition advice code identifies the general category of purchasers of an item. It is input from cataloging data through the Stock Control and Distribution System (D032). In this Appendix, we discuss the accuracy of this code.

ACCURACY OF THE CODE

When we began our analysis, we needed a way to identify items used in support of depot level maintenance. We were led to the acquisition advice code. The acquisition advice code is a code placed on an item when it is first introduced into the inventory. The item manager assigns the code during the Catalog Management Data (CMD) phase. When an item is being cataloged, the repair process must be known, as well as how the item will be acquired by the retailer. The acquisition advice code signifies how the item will be purchased: local purchase, on contract, available to all bases, or restricted to certain users.

Over time, the use of an item may vary. A new repair process might alter the list of approved purchasers, causing the old code to be wrong. It is here where problems may arise. An item manager might not change the acquisition code to reflect the most up-to-date usage.

Table A-1 is a breakdown of codes in our database.[2]

ACQUISITION ADVICE CODE

CODE	DESCRIPTION	NUMBER IN OUR DATABASE	PERCENT
D	(GENERAL ISSUE)	54,724	76.0%
M	(RESTRICTED REQUISITION-MAJOR OVERHAUL)	11,834	16.4%
Z	(INSURANCE)	3,646	5.1%
V	(TERMINAL ITEM)	833	1.2%
C	(SERVICE MANAGED)	530	0.7%
P	(RESTRICTED REQUISITION-SECURITY ASSISTANCE)	399	0.6%

Table A-1

In our analysis, 76 percent of all the items had an acquisition code of 'D'. These are general issue items, available

to any user. They are centrally managed, stocked, and issued. Only 16.4 percent of the items in our data are coded 'M'. These are restricted requisition, major overhaul items. Only those purchasers authorized to perform major overhaul functions will be allowed to requisition these items. Logically, items coded with an 'M' should be Depot Level Maintenance (DLM) items only.

Table A-2 shows a breakdown of demand type for items in our database with an acquisition advice code of 'M'.

ACQUISITION ADVICE CODE OF 'M'
(TYPES OF DEMANDS)

TYPE OF DEMAND	NUMBER	PERCENT
NO PAST DEMAND	7,884	66.6%
DEPOT SALES	1,482	12.5%
MULTIPLE DEMANDS	1,335	11.3%
BASE TRANSFERS	1,133	9.6%

Table A-2

Table A-2 shows most of these items (66.6 percent) had no demand for the past two years. Only 12.5 percent had demands that were either depot or contract sales over the past couple of years. Under ten percent of the demands involved just base transfers and the remaining items had multiple types of demands.

The items with base transfers or multiple demands are not exclusively DLM items. Therefore, they should not have a code of 'M'. It is difficult to say whether the items with no demands should have a code of 'M'. In our study of items with DLM projections, just over 18 percent of the items had exclusively past depot or contract demands. Out of those items, only 18 percent were actually coded 'M'. Either these items have the wrong code or the wrong items are getting the DLM projections. Less than 20 percent of the items having only depot or contract sales have projections and less than ten percent of all the items coded 'M' have DLM projections.

ANOTHER SHORTCOMING

According to AFLCR 57-6, depot level maintenance requirements projections (type 'A' computation) are designed for items used in support of depot level maintenance.[1] This means that any item which has depot or contract sales is an item which is used in support of depot level maintenance. In our study of items having positive DLM projections, 79 percent of the items had some sort of depot or contract demands. Either the items were exclusively DLM items (18 percent) or they were DLM items with other types of demands (61 percent). As stated earlier, an acquisition advice

code of 'M' defines an item to be used only for depot level maintenance, but there is no code to identify the items used in support of depot level maintenance, which are also used by other bases.

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2. Department of the Air Force. USAF Supply Manual. AFM 67-1. Washington D.C.: HQ USAF, 7 Dec 87.

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