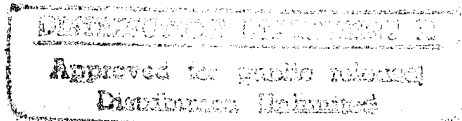




DLA-96-P40251

ANALYSIS OF LOW DEMAND ITEMS



JUNE 1996

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INSIGHT THROUGH ANALYSIS

DORO

DLA-96-P40251

ANALYSIS OF LOW DEMAND ITEMS

JUNE 1996

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FOREWORD

In recent years several paramount DOD changes have impacted DLA: consumable item transfers, force reductions, and the adoption of new business practices such as the Defense Business Operating Fund (DBOF). One of many resulting DLA initiatives is the re-evaluation of the management policy for low demand items. Currently, DLA is responsible for managing over four million items of which eighty percent are low demand. These items account for roughly half of agency inventory investment or about five billion dollars. This is a substantial investment in a large number of items managed with a policy based on rule of thumb. This study provides a quantitative foundation for the current policy and recommends additional areas of improvement.

A handwritten signature in black ink, appearing to read "H. Bankirer", is positioned above the printed name.

HAROLD BANKIRER
Colonel, USA
Chief, DLA Operations Research Office

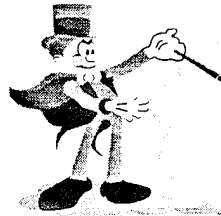
EXECUTIVE SUMMARY

In recent years several paramount DOD changes have impacted DLA: consumable item transfers, force reductions, and the adoption of new business practices such as the Defense Business Operating Fund (DBOF). One of many resulting DLA initiatives is the re-evaluation of the management policy for low demand items. Currently, DLA is responsible for managing over four million items of which eighty percent are low demand. These items account for roughly half of agency inventory investment or about five billion dollars. This is a substantial investment in a large number of items managed with a policy based on rule of thumb.

This study provides a quantitative foundation to the current policy and recommends additional areas of improvement. Using five years of historical demand, a simulation model is employed to explore variations to the current low demand item management policy (Numeric Stockage Objective or NSO) and Economic Order Quantity (EOQ) technique normally used for high demand items.

Study results show that the NSO policy has performed well when compared to other heuristic driven policies. However, improvements can be made. The most promising improvements are recommended for test implementation at the DLA Supply Centers and they are: extending item NSO computations from considering four quarters to eight quarters, weighting more recent demand, adjusting quarterly updates of item buy quantity, and including leadtime demand in the NSO computation.

BACKGROUND



IF $ADF < 4$ OR $ADQ < 12$
THEN "LOW DEMAND"

IF "LOW DEMAND"
THEN NSO POLICY

- 80% OF DLA ITEMS ARE LOW DEMAND ITEMS (3 MILLION)
- LOW DEMAND ITEMS ARE A SIGNIFICANT INVENTORY INVESTMENT (50% OR \$5 BILLION)
- SPARSE AND INCONSISTENT DEMAND IMPEDES ITEM MANAGEMENT
- ITEM MANAGEMENT IS BY RULE OF THUMB



IF EVEN SMALL IMPROVEMENTS COULD BE FOUND, THEY
WOULD BE WORTHWHILE

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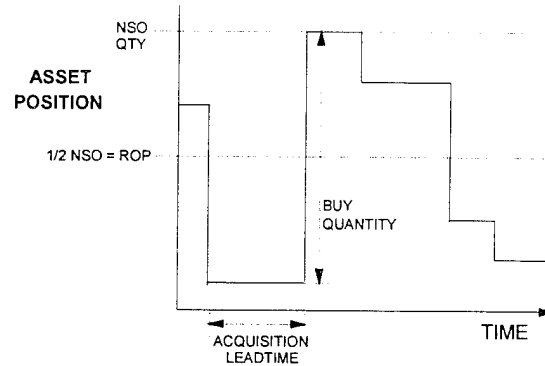


In recent years several paramount DOD changes have impacted DLA: consumable item transfers, force reductions, and the adoption of new business practices such as the Defense Business Operating Fund (DBOF). One of many resulting DLA initiatives is the re-evaluation of the management policy for low demand items. Currently, DLA is responsible for managing over four million items of which eighty percent are low demand.

Low demand items historically represent only a small fraction of DLA's demand, thereby getting much less attention than high demand items. Items are designated low demand if in the past year there were less than four requisitions or less than twelve units requisitioned. These low and inconsistent demand patterns defy the assumptions required by inventory techniques for managing high demand items. Hence, a rule of thumb item management procedure known as Numeric Stockage Objective or NSO is used.

These items account for roughly half of agency inventory investment or about five billion dollars. This is a substantial investment in a large number of items managed without quantitative foundation. Even small improvements to the current item management policy could produce significant savings.

BACKGROUND



- NUMERIC STOCKAGE OBJECTIVE POLICY - LOW DEMAND
- NSO QUANTITY IS EQUAL TO THE ANNUAL DEMAND
- REORDER POINT IS ONE-HALF THE ANNUAL DEMAND QUANTITY
- REORDER QUANTITY REPLENISHES BACK UP TO THE NSO

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Historically, the NSO policy has been used to determine requirement levels for low demand items. An NSO quantity is set at the current annual demand quantity. The annual demand quantity corresponds to the total quantity of items requisitioned during the past year. The reorder point (ROP) is one half the NSO quantity and the buy quantity is the NSO minus the asset position.

Note that unlike most inventory schemes, the NSO policy decides when to reorder independently of the length of time to receive the order. The time required for the procurement is measured by the acquisition lead time which is the sum of the administration and production lead times. This lead time is not a part of the NSO policy, but is introduced as one possible policy improvement which will be discussed later.

Each item's NSO, ROP and buy quantity are updated each quarter with the latest quarter's transactions. With no demand over the last four quarters, the item is transitioned to a non-stocked status. With a big enough increase beyond the low demand definition in the last four quarters, the item is reclassified as a replenishment item to be managed by economic order quantity (EOQ) methods.

OBJECTIVES

- DETERMINE THE BEST LOW DEMAND ITEM MANAGEMENT POLICY PER COMMODITY
- DEVELOP AN APPROACH FOR EXAMINING LOW DEMAND ITEM DEFINITIONS

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The primary objective of this study is to determine the best overall low demand item management policy for each commodity.

The secondary objective of this study is to develop an approach for examining various definitions for low demand items. For example, it might be found that Construction low demand items are better characterized as having less than five requisitions per year or less than twenty units of issue instead of the current definition.

MANAGEMENT POLICIES UNDER STUDY

- NSO BASELINE
- NSO VARIATIONS
 - REORDER POINT
 - BETTER FORECASTING
 - » EXTENDED DEMAND WINDOW
 - » WEIGHTED DEMAND WINDOW
 - BUY QUANTITY
 - LEADTIME DEMAND
- EOQ AND VARIATIONS

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The NSO policy serves as the baseline for our efforts to find the best alternative for low demand item management. Variations to this baseline, as well as EOQ and variations to EOQ, form the list of alternatives.

Initial baseline variation study efforts examine ROP variation above and below the baseline value of one-half. Analysis of demand forecasting follows with particular attention towards extending the NSO four quarter demand window, and applying various weighting schemes. The next area of study involves quarterly adjustments to buy quantity, and finally employing leadtime demand quantity to reduce stockouts of longer leadtime items.

Analysis concludes with EOQ application to low demand items and an EOQ variation that includes a leadtime forecasting component.

MANAGEMENT POLICY ANALYSIS

- **MAJOR ASSUMPTIONS**
- **DATA DEVELOPMENT**
- **PERFORMANCE MEASURE SELECTION**
- **DEVELOP MODEL FOR COMPARING POLICY ALTERNATIVES**
- **EVALUATE AND COMPARE ALTERNATIVES**
- **RESULTS**
- **CONCLUSIONS**
- **RECOMMENDATIONS**

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In order to study various methods for managing low demand items, a model was created that approximates item inventory management. Discussion of this model, centered on the topics presented in this chart, provides the balance of this annotated briefing.

MANAGEMENT POLICY ANALYSIS

MAJOR ASSUMPTIONS

- **5 YEARS OF DEMAND HISTORY ARE SUFFICIENT**
- **YEARLY AVERAGES FOR ITEM PRICES & ACQUISITION LEADTIMES ARE REPRESENTATIVE**

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As with every study there are simplifying assumptions that render the study area tractable, yet maintain a reasonable real world representation. Two assumptions provide the general context for this study. The first assumption is that five years of demand history are sufficient to study low demand item inventory policy. This choice balances the ten years other studies have used with the significant policy and structural changes DOD and DLA in particular has undertaken in the past five years. The second assumption is that yearly averages for item price and acquisition lead time are sufficient for this study. Originally, five year averages for each item were used, but subsequent data review showed significant data trends such as price increases and leadtime decreases. These trends were accommodated by moving from five year averages to yearly averages.

MANAGEMENT POLICY ANALYSIS DATA DEVELOPMENT

- **ITEMS WITH LOW DEMAND HISTORY**
- **5 YEARS OF DIDB DATA**
- **HARDWARE ITEMS, STOCKED AND DLA MANAGED**
- **EXCLUDE CIT ITEMS**
- **USE REQUISITIONS FOR DEMAND DATA**
- **TOTAL - 205K ITEMS AND 4.5M REQS.**

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Common with typical inventory studies, this effort considers many years of activity involving large numbers of items. Items with historically low demand activity were study candidates if they had at least two and at most nineteen requisitions during the five year period from July 1989 thru September 1994. Furthermore, each item must have had at least one procurement during the five year period. The DLA Integrated Data Base (DIDB) provided the five years of demand history required.

Items must be stocked hardware (Construction, Electronic, General and Industrial Commodities) items under DLA management. Consumable Item Transfer (CIT) items are excluded since they in general do not have enough DLA demand history. These data constraints result in an item population of two hundred five thousand and a related demand history of four and one-half million requisitions over the five year period.

MANAGEMENT POLICY ANALYSIS

PERFORMANCE MEASURE SELECTION

- **CUSTOMER SATISFACTION AND SYSTEM COST**
 - SUPPLY AVAILABILITY
 - SYSTEM COST (HOLDING AND ORDERING)
- **COMBINED PERFORMANCE MEASURE TO CAPTURE THE BEST BALANCE**



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Since this study is a comparison of inventory policies, the choice of performance measures is critical. Consistent with the agency emphasis to improve customer service at reduced cost, the general measures of performance are customer satisfaction and system cost. An added complication is the interaction of these two measures, generally marked by higher cost for better customer service. Thus, with two performance measures it is difficult to make a final decision on the "best" policy. This study captures the essence of these performance measures and takes the extra step of combining them into a single measure easing policy comparison.

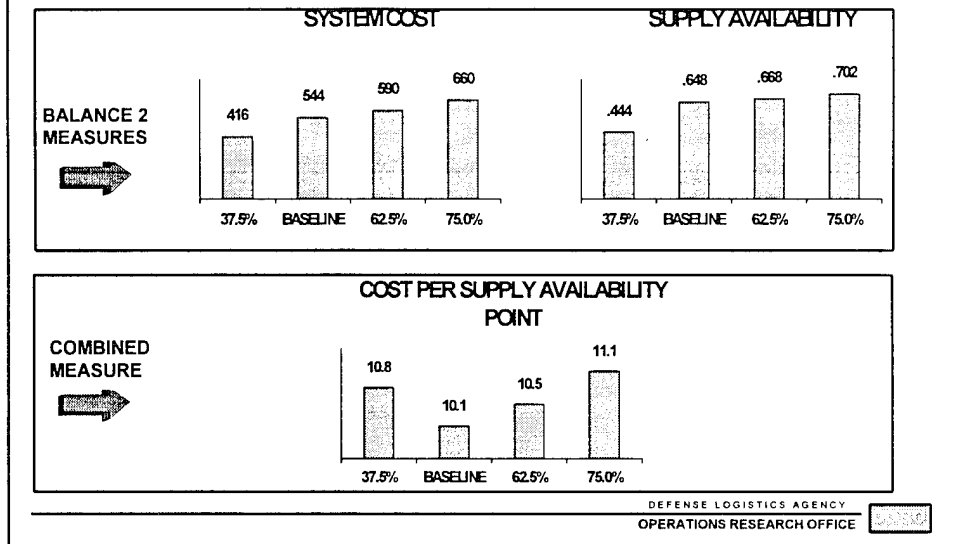
Customer satisfaction is represented by Supply Availability, which for this study is defined as the number of satisfied requisitions divided by the total number of requisitions per item. If any part of a requisition is backordered, the requisition is not satisfied.

System cost for each item is measured as the sum of the cost to hold an item and the cost to order an item over the five years. The cost to hold an item was based on the 1993 Synergy Cost to Hold Study where the figure varies by commodity. This study uses a single average figure of 17% of an item's inventory value. The cost to order an item uses the small manual order cost by commodity taken from the 1989 Synergy Multiple Cost EOQ study. The order costs in dollars for the Construction, Electronics, General and Industrial commodities are \$95, \$93, \$88 and \$96, respectively.

The combined measure for policy comparison representing the interaction of supply availability and cost is the cost to move supply availability one point. This measure is discussed in more detail on the following page.

MANAGEMENT POLICY ANALYSIS

VALUE OF A COMBINED PERFORMANCE MEASURE

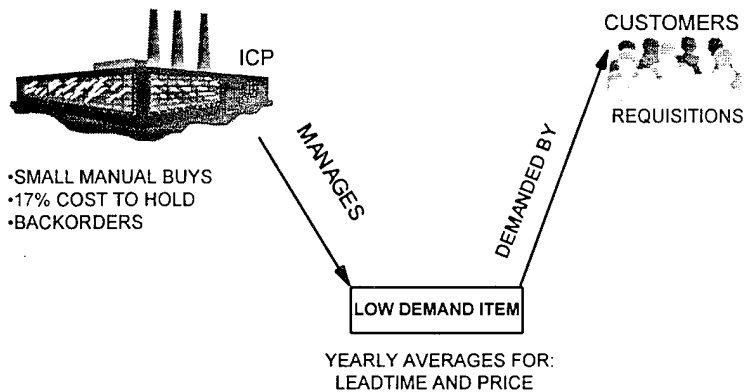


The results presented in these examples emphasize the need for a combined measure. For example, when balancing two performance measures as in the top box above, compare the baseline to the "62.5%" policy. Notice the baseline has lower system cost, but lower Supply Availability. How does one determine the better policy ?

In the bottom box one can see the convenience of a single combined measure where the better choice has the smallest bar. This combined performance measure is the overall policy average of individual item costs in dollars to move supply availability one point, say from 65% to 66%. The policy with the lower cost per supply availability point can be viewed as more cost effective for the same performance.

MANAGEMENT POLICY ANALYSIS

DEVELOP MODEL

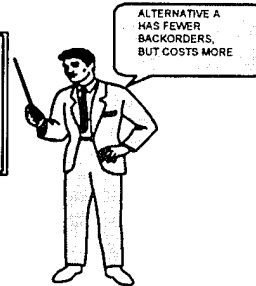
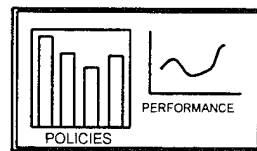


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The study vehicle for inventory policy analysis is a deterministic simulation model that was built in support of modernization of DoD inventory standard systems. This current effort can be viewed as an extension that includes low demand inventory analysis capability. The model approximates customer requisitioning of inventory items and DSC management in support of requesting customers. The essence of the model is the representation of the history of item requisition processing. To study a particular inventory policy impact, the policy is applied to the item's requisition history. The study is essentially replaying history with different policies in effect. This is especially significant for low demand items whose demands are few and inconsistent to begin with.

MANAGEMENT POLICY ANALYSIS

EVALUATE AND COMPARE ALTERNATIVES



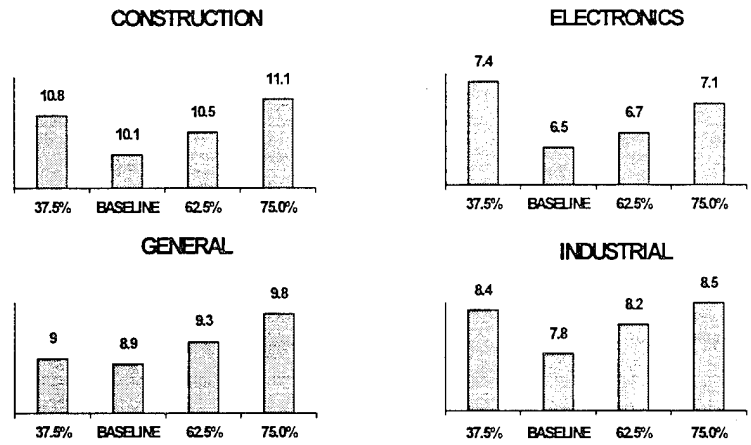
- THE BEST MANAGEMENT POLICY FOR AN ITEM WILL STRIKE THE BEST BALANCE BETWEEN SUPPLY AVAILABILITY AND SYSTEM COST
- COST PER SUPPLY AVAILABILITY POINT

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To recap, the study background and major assumptions have been discussed. Data development followed with the selection of items under study. Demand histories and item parameters such as price are manipulated by the various inventory alternatives resulting in cumulative performance measure output. This output is compared across the inventory policy alternatives where the cost per supply availability point determines the best alternatives. With this in mind, we can review the following results.

STUDY RESULTS

ROP - COST(\$) PER SUPPLY AVAILABILITY POINT

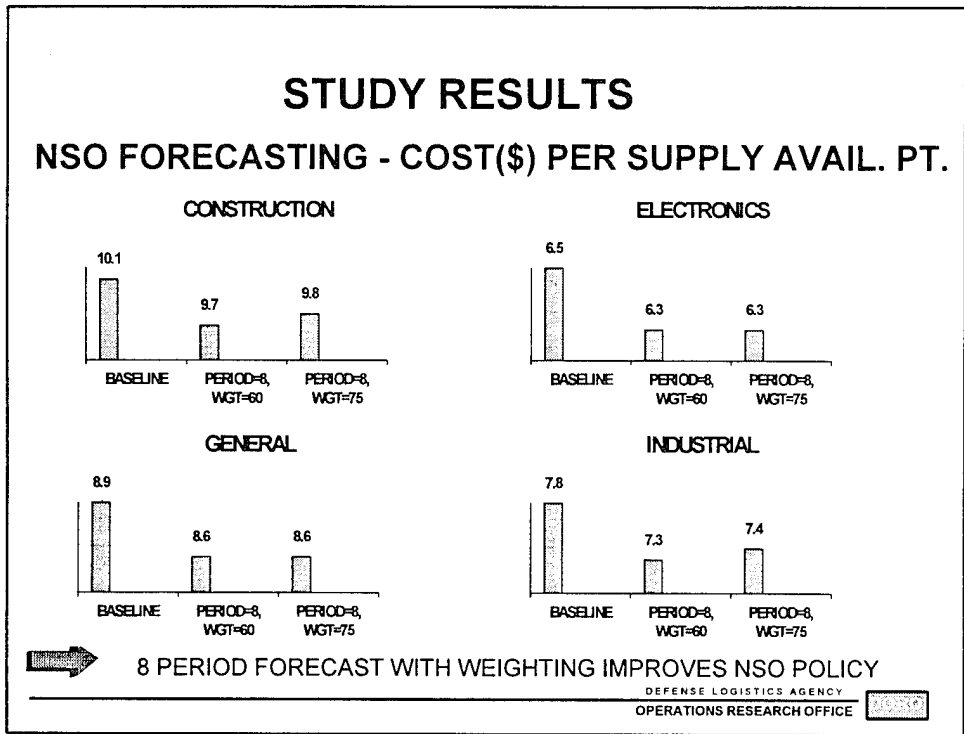


HISTORICAL NSO HEURISTIC ROP=ADQ/2 PERFORMS BEST

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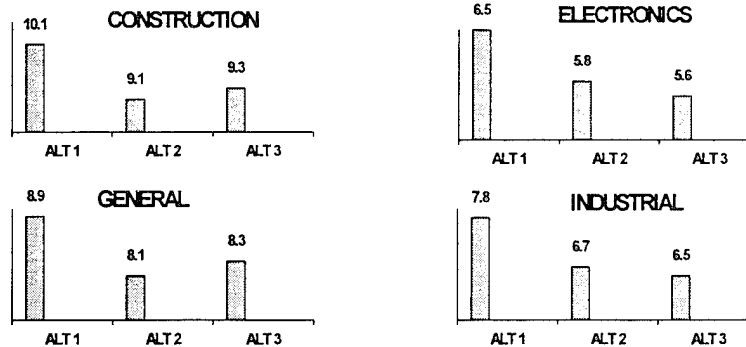
Initial analysis work concentrates on ROP variations to the baseline NSO policy. The reorder point heuristic of one-half the annual demand quantity varies along the range of values indicated. The results are consistent across commodities. The baseline is the best in terms of the single combined measure of average item cost per supply availability point.



Given that the historical baseline is an effective inventory management scheme for low demand items, various extensions to the baseline are explored. The most obvious extensions are forecasting improvements. The first improvement involves the length of demand history used in computing the NSO quantity. Historically, one year's worth of demand has been used, but a natural extension is to increase this time period for a more complete picture of low demand behavior. This study examines an eight quarter demand history (period equal to eight) and finds improvement across commodities. The above charts show improvement over the baseline for the eight quarter alternative using a weighted average. The weighting schemes allow the more recent four quarters demand to receive more weight. Two weighting schemes displayed the best results. These were 40/60 and 25/75. "40/60" refers to the oldest four quarters of demand receiving a forty percent weighting factor while the most recent four quarters receive a sixty percent weight. The same notation applies to 25/75. Notice that 40/60 improves on the baseline while 25/75 is better than the baseline, but not as much as the 40/60 alternative. This suggests that weighting helps to a point.

STUDY RESULTS

BUY QUANTITY - COST(\$) PER SUPPLY AVAIL. POINT



LEGEND

ALT 1 - BASELINE

ALT 2 - BUY QUANTITY ADJUSTMENT USING AVERAGE REQUISITION SIZE IF BIGGER (WITH FORECASTING)

ALT 3 - BUY QUANTITY ADJUSTMENT USING SUM OF BUY QUANTITY AND AVG REQ SIZE (WITH FORECASTING)

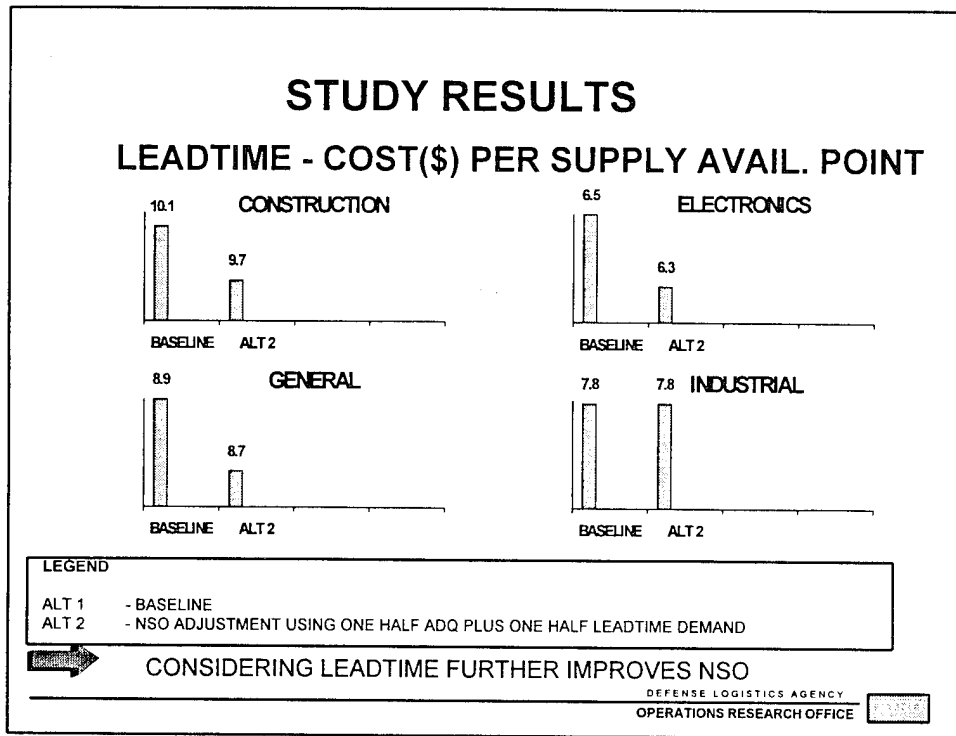


BUY QUANTITY ADJUSTMENTS FURTHER IMPROVE NSO

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Other options for more effectively managing low demand items involve alternative buy quantity computations. Recall that the DLA supply system updates inventory management data such as buy quantity for each item based on the item's activity during the quarter. The most promising adjustments tested are alternatives two and three above. Alternative two looks better than the baseline for the construction and general commodities. This computation takes the baseline buy quantity and substitutes the average requisition quantity whenever it exceeds the baseline buy quantity. Alternative three looks better than the baseline for the electronics and industrial commodities. This computation takes the baseline buy quantity and adds the average requisition quantity. These alternatives also include the forecasting improvements discussed before.

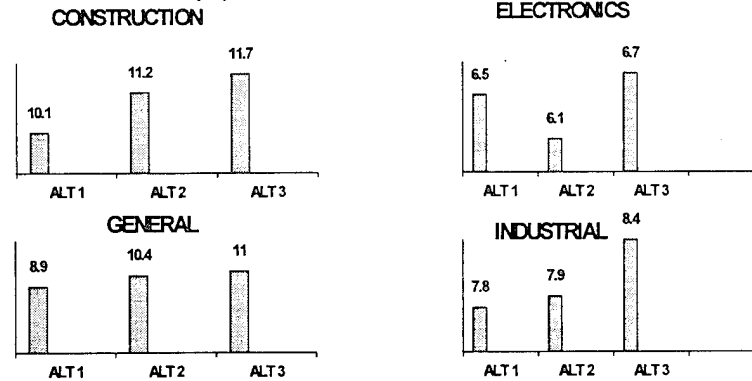


Another potential improvement in low demand item management involves utilizing leadtime demand quantity. The NSO policy does not consider acquisition leadtime. Except for industrial items, alternative two results in noticeable improvements to the baseline. This alternative sets the NSO equal to the sum of one-half the annual demand quantity and one-half the leadtime demand. Additional alternatives were studied adding forecasting and buy quantity adjustments in combination with leadtime, but no improvement was found.

In an effort to find additional leadtime advantages, further analysis using larger multiples of leadtime (one, one and a half years and two years respectively) was performed. Although detailed results are not presented here, the net effect was that holding costs skyrocketed to a prohibitive level. In summary, leadtime adjustments by themselves show significant improvement except for industrial items.

STUDY RESULTS

EOQ - COST(\$ PER SUPPLY AVAILABILITY POINT



LEGEND
 ALT 1 - BASELINE
 ALT 2 - EOQ
 ALT 3 - ALT 2 WITH PERIOD DEMAND FORECAST (PDF) = MINIMUM OF PDF AND LEADTIME DEMAND



CONSIDERING EOQ SHOWS IMPROVEMENT FOR ELECTRONICS

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The Economic Order Quantity (EOQ) based alternatives are the last set to explore. EOQ techniques are cost based and assume constant demand. This inventory policy has historically been used to manage replenishment items which come much closer than low demand items to meeting the requisite assumptions (constant demand mainly). The assumption of constant demand renders the low demand items poor candidates for this item management policy. Study results back up this statement with the exception of the Electronics commodity. When compared to the NSO baseline, EOQ results show fewer buys and less ordering costs, but much larger inventories. The resultant higher holding costs more than outweigh ordering cost efficiencies. To lower the holding costs, an alternative variation (alternative three in the chart) of EOQ is tested. Under this alternative the period or quarterly forecast is reduced by substituting a quarter's worth of leadtime demand for the quarterly forecast when it is less. This alternative did lower holding costs, but the resulting increase in ordering costs actually caused a higher cost for the alternative. Two similar variations tested showed even greater costs than alternative three. One variation substituted leadtime demand when it was greater and the other variation substituted leadtime demand for period demand forecast without qualification.

CONCLUSIONS

- HISTORICAL NSO HEURISTIC OF $ROP=ADQ/2$ IS A GOOD ONE
- FORECAST WINDOW EXTENSION AND WEIGHTING YIELDS SIGNIFICANT IMPROVEMENT TO NSO POLICY
- BUY QUANTITY ADJUSTMENTS SUCH AS USING THE AVERAGE REQUISITION QUANTITY WHEN IT EXCEEDS THE BUY QUANTITY IMPROVES LOW DEMAND MANAGEMENT
- CONSIDERING LEADTIME DEMAND IN CONCERT WITH NSO POLICY SIGNIFICANTLY IMPROVES LOW DEMAND MANAGEMENT
- EOQ MANAGEMENT PERFORMED BETTER FOR COMMODITY E, BUT WORSE FOR C, I AND G

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The primary study objective is to find the best low demand item management policy. The historical NSO policy serves as the baseline for comparison and provides a tougher than anticipated starting point. The NSO heuristic outperforms a range of potential replacements.

Forecast window extensions including moving from four to eight periods and weighting the most recent periods improve the baseline results across all commodities.

Quarterly update adjustments to the buy quantity computation add additional improvements beyond the forecasting enhancements.

Considering leadtime demand combined with the basic NSO baseline shows improvement, but when combined with the forecast and buy quantity changes shows almost no impact. In general adding to inventory to cover longer leadtime items is of marginal benefit.

EOQ techniques show some promise for the Electronics commodity while the other commodities perform poorly under EOQ. Electronics items have much smaller inventories, hence holding cost increases are much smaller.

CONCLUSIONS ON APPROACH FOR ANALYSIS OF LOW DEMAND DEFINITION

A PROCESS WAS DEVELOPED TO PERFORM DETAILED LOW DEMAND DEFINITION ANALYSIS

- DEFINE ITEM DESCRIPTIVE DATA SUCH AS ADF, ADQ OR ALT
- DETERMINE PERFORMANCE MEASURES SUCH AS SUPPLY AVAILABILITY, TOTAL COST, EXPECTED BACKORDERS OR COST PER SUPPLY AVAILABILITY POINT
- AGGREGATE ITEMS BY DESCRIPTIVE DATA
- ORDER AGGREGATES BY PERFORMANCE MEASURE
- GROUP ITEMS INTO CATEGORIES WHERE APPLICABLE

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Recall that the secondary objective of the study was to develop an approach for refining commodity level policies by examining the definitions used to delineate "low demand." A general approach has been developed and can be implemented with the model built for the policy evaluations. Subcategories of items could be identified that have the same performance measure and fall within various ranges of values of Annual Demand Frequency, Annual Demand Quantity and Acquisition Leadtime. One could then examine alternative policies for these subcategories.

RECOMMENDATIONS

- **COORDINATE WITH INVENTORY CONTROL POINTS TO TEST STUDY RESULT IMPLEMENTATION**
- **ADDITIONAL STUDY TO EXTEND APPROACH FOR LOW DEMAND ITEM DEFINITION ANALYSIS TO RECOMMEND IMPROVED MANAGEMENT POLICY PER CATEGORY OF LOW DEMAND ITEMS**

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This study demonstrates the effectiveness of the historical NSO policy and shows where improvements can be made. Given the large number of low demand items, and their significant inventory investment, this study recommends using selected DLA Supply Centers to test implementation of study results.

This study developed an approach for low demand item definition analysis. Additional study is recommended to extend this work using data already developed. The goal would be to use study data to recommend inventory policies for specific item groups within various commodities.

REPORT DOCUMENTATION PAGE

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