ECONOMIC RETENTION IN THE DEPARTMENT OF DEFENSE

A RISK PERSPECTIVE

REPORT LG608T1

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Executive Summary

To manage defense inventory is to manage risk. Uncertainties in demand and lead-time make inventory investment a risky decision. Defense inventory managers carry safety stock to hedge against these uncertainties. Sophisticated mathematical models calculate the extent of risk and the cost of avoiding it; they also optimize overall inventory investment. But the question of retaining or disposing of what appears to be surplus inventory also carries risk. It, too, is subject to demand uncertainties.

Complicating the issue of economic retention is the 2005 Base Realignment and Closure (BRAC) decision, which consolidated collocated inventories at a number of DoD industrial facilities and projected significant savings to be realized from reducing occupied warehouse space.

Among the DoD components managing secondary items (i.e., the military services and the Defense Logistics Agency), only the Army uses a mathematical model to determine economic retention limits (ERL). A recent LMI study for the Air Force developed risk-based ERL rules for reparable items. Subsequently, LMI was tasked to conduct similar analyses for the other components.

Our analysis found the following:

- The risk of repurchasing inventory after disposal is high, and it varies among the components as well as among item groups within a component. This risk is high enough that repurchase should be looked upon as a *probability* rather than a *possibility*, and the retain-or-dispose decision should be thought of in terms of planning for repurchasing, rather than as the immediate question of disposition of stock. This is consistent with previous studies in this area.

- Savings from reduced inventory levels are very low and do not offset the repurchase cost.

- Storage cube reductions can be realized with lower retention limits, but other categories of inventory may be better candidates for disposal. At only 8 percent of the total, economic retention stocks do not offer much opportunity for large reductions in inventory.

- Economic retention limits, in general, should be on the order of at least 20 years of demand for most items.

We therefore conclude that, without specific information about an item's future demand, reducing retention limits to achieve storage cost savings is not cost-effective. Our recommendations are in two areas: economic retention policy and addressing storage savings.

Economic Retention Policy. We recommend DoD revise DoD 4140.1-R, *DoD Supply Chain Materiel Management Regulation*, as follows:

- Refocus emphasis from a retention or disposal decision to a repurchase decision, since repurchase is the main cost driver.

- Call for DoD components to track repurchase metrics.

- Include, under procedure sections, additional techniques for more accurately determining the probability of future demand or repurchase.

- Include, under procedure sections, a linking of materiel retention or repurchase to item reduction.

Achieving Storage Cost Savings. We recommend DoD consider other avenues to achieve reductions in inventory:

- Take a closer look at contingency retention, which has grown dramatically in recent years and is significantly greater in volume than economic retention.

- Disposal reviews and action on stocks already classified as potential reutilization or disposal stocks (PRDS) should be more aggressive. Focus on the highest cube items.

- Shift high cube items to direct vendor delivery, but only after ensuring customer support and surge capability can be maintained and costs do not offset savings.

- Accelerate efforts to link wholesale and retail inventory levels via multiple-echelon modeling, which can produce inventory savings on the order of 10 percent.

- Monitor demand forecasting methods for positive bias, which can lead to overinvestment in inventory.

Contents

Figures

Tables

Economic Retention: A Risk Perspective

This study addresses the retention of materiel in the DoD supply system. Specifically, it deals with the economic aspects of retaining already purchased materiel.

WHAT IS THE RETENTION DECISION?

To satisfy the needs of military customers throughout the world, the Department of Defense maintains an inventory of more than 5 million different secondary items of supply, valued at more than $85 billion.[1] Most of these items are repair parts for weapon systems, but the inventory also includes personnel support items (e.g., food, clothing, and medical materiel), as well as construction materials and packaged petroleum products.

Inventory levels are set and acquired based on anticipated future customer demand. Key decisions to the inventory acquisition process are when to buy and how much to buy. Those decisions are made difficult by uncertainties in both customer demand and the lead-times required to resupply inventory levels. Over time, if changing customer needs cause demand to decline, DoD materiel managers may find themselves with inventory that appears to be above what is needed within their approved acquisition objective (AAO). When this happens, managers must decide what portion of that inventory to retain and what portion to dispose of.

DoD policy requires the retention decision be made on an economic basis (i.e., retain or dispose according to the respective costs); however, demand uncertainty plagues the retention decision. It introduces the risk of repurchasing materiel that was once owned but disposed of.

Much of this study deals with how to manage that risk.

WHAT WE WERE TASKED TO DO

Over the years, LMI has conducted a number of studies of economic retention. All generally led to the same conclusion: The risks and costs associated with disposing of and then repurchasing materiel far outweigh the cost of retaining the stock.

[1] DoD, *Supply System Inventory Report* (SSIR), September 30, 2006.

This study is a continuation of those earlier studies. It was motivated by two events:

- While $11 billion of the DoD inventory is at retail supply activities close to the military customers it supports, $74 billion is wholesale inventory held primarily in 25 distribution centers around the world, mostly in the continental United States, and occupies more than 100 million cubic feet of storage space. The 2005 Base Realignment and Closure (BRAC) decision consolidated collocated retail and wholesale inventories at a number of DoD industrial facilities, and projected significant savings to be realized from reducing occupied warehouse space. To achieve those savings, the Defense Logistics Agency (DLA) is looking for ways to reduce space requirements, including reductions in dormant stocks.[2]

- The last work that LMI performed on economic retention was done for the Air Force, and included some new techniques for accommodating demand uncertainty. The final report was well received by the Air Force. Because the techniques would result in more retention stocks, the Air Force briefed the work to the Assistant Deputy Under Secretary of Defense for Supply Chain Integration (ADUSD[SCI]) in June 2006.[3]

In light of these events, SCI tasked LMI to repeat the Air Force analysis for the other military services and DLA, and to consider in all analyses the recent BRAC decisions on wholesale storage space.

How We Approached Our Tasking

Our approach had three objectives:

- Establish a baseline for studying policy improvements for economic retention by reviewing current economic policy, principles, and practices.

- Determine what policy changes should be pursued based on a repetition of the Air Force demand variability analysis for the Army, Navy, and DLA.

- Determine what policy changes should be pursued based a storage analysis of economic retention stocks (ERS).

[2] Dormant stocks are initially defined as stock that hasn't had a demand or new procurement in 2 years. Items meeting these criteria are reviewed for possible disposal.

[3] SCI is responsible for OSD materiel retention policy.

BASELINE FOR IMPROVING ECONOMIC RETENTION

What Is Current DoD Policy on Materiel Retention?

Current policy requirements and procedures governing economic retention are outlined in Section C2.8, *Materiel Retention*, of DoD 4140.1-R, *DoD Supply Chain Materiel Management Regulation*. In terms of requirements, section C2.8 states:

> C2.8.1.1.1.2. ERS is stock above the AAO that is more economical to retain than to dispose of. To warrant economic retention, an item should have a reasonably predictable demand rate. If the expected demand for an item is not predictable, yet the expectation for future demand is probable, the item may still have ERS provided the managing DoD Component has a documented rationale that economically justifies retention and is available for audit purposes.
>
> C2.8.1.1.2. To ensure that economic and contingency retention stocks correspond with current and future force levels, the DoD Components shall review and validate their methodologies for making economic and contingency retention decisions. The review shall occur at least annually, and the inventory management organization Commander, or designee shall attest to its validity in writing.

In terms of procedures, section C2.8 explains:

> C2.8.1.2.1. The methodology used to set the maximum level of ERS for an item, that its economic retention level, should be based on an economic analysis that balances the costs of retention and the costs of disposal. The DoD Components should consider in the economic analysis the costs of retaining items, the potential long-term demand for the items, potential repurchase costs, and, for items essential to the operation of a weapon system, the expected life of the system, and the number of systems in use. The analysis may be accomplished on an item-by-item basis or for logical commodity groupings or specific end item applications.
>
> C2.8.1.2.3. The DoD Components' review of economic retention methodologies should focus on:
>
> > C2.8.1.2.3.1. Better analyses supporting retention decisions by using forecasting models that take into account potential upward or downward trends in demand and/or the uncertainties of predicting long-term demand based on historical data.
> >
> > C2.8.1.2.3.2. Improved estimates for costs used in retention decision-making.

In short, the regulation calls for the use of economic analysis to determine how much materiel already purchased should be retained and how much should be disposed of.

How Does Economic Analysis Apply to Materiel Retention?

The basic concept of an economic retention decision is to compare two alternatives: Given a quantity of stock for an item, what are the costs associated with keeping that quantity in inventory versus disposing of it. For each decision (retain or dispose) the major influencing factors are the cost of storage, the salvage value, the cost of repurchasing disposed materiel, and the likelihood of demand for the disposed quantity.

THE COST OF STORAGE

If a materiel manager retains a quantity of an item and it is demanded in some future year, he pays a storage cost for the intervening years. If it is never demanded over the time horizon, he pays for storage over the entire time.

Storage cost has traditionally been expressed as a function of the dollar value of the materiel stored. Over the years, the total cost of storage averages less than 1 percent of the value of the inventory. In light of stepped up efforts to reduce storage cube, we also evaluated higher storage cost rates.

THE COST OF REPURCHASING MATERIEL

If a materiel manager disposes of a quantity of stock and it is demanded in some future year, he pays a repurchase cost in that future year. In this study, we used the current cost of the item to measure this cost, even though anecdotal evidence suggests that it may cost several times today's cost to buy the item, if it is available at all.

SALVAGE VALUE

When the Department disposes of inventory through the Defense Reutilization and Marketing Service (DRMS), it may be reutilized by other government agencies, donated to eligible organizations, or sold to private individuals or businesses. In some cases it may need to be de-militarized before sale. Historically, the average amount realized from sales by DRMS is between 2 and 3 percent of the items' value,[4] but this does not consider reutilization. We increased the rate to 5 percent for this analysis to account for the benefits of reutilization.

[4] Since 1993, the average salvage value for a year is listed in the SSIR.

ECONOMIC RETENTION LIMITS

The cost models for economic retention are well developed. Kruse[5] developed a straightforward retention cost model for DLA in 1997. Bachman and Burleson[6] developed a similar model for reparable items, and Zimmerman[7] developed a net-present-value model for consumable items based on the difference between savings (rather than cost) from disposing versus retaining a quantity of stock. We will not redevelop the economic retention models here. We used the basic approach from Kruse:

The expected marginal cost to dispose for a retention level of N units is

$$ECD(N) = -v \cdot up + \sum_{j=1}^{H} \frac{up \cdot f_N(j)}{(1+i)^j}; \qquad \text{[Eq. 1]}$$

and the expected marginal cost to retain for a retention level of N units is

$$ECR(N) = s \cdot up \sum_{j=1}^{H} \frac{1 - F_N(j)}{(1+i)^j}, \qquad \text{[Eq. 2]}$$

where

N	=	number of units in the level, or the multiplier for forecasted annual demand
$ECD(N)$	=	expected marginal cost to dispose for level N
$ECR(N)$	=	expected marginal cost to retain for level N
up	=	unit price (acquisition cost)
v	=	salvage cost factor
up	=	buyback (repurchase) cost—unit price
H	=	number of periods in the time horizon
$f_N(j)$	=	probability of depleting level N in period j
$F_N(j)$	=	probability of depleting level N by period j
i	=	discount rate
s	=	storage cost factor.

[5] LMI, *Defense Logistics Agency Economic Retention Policy*, Report DL604R1, Karl Kruse et al., August 1997.

[6] LMI, *Economic Retention Levels for Air Force Reparable Items*, Report AF701R1, Tovey C. Bachman and Robert E. Burleson, July 1999.

[7] LMI, *Economic Retention Within the Department of Defense*, Report LG301T1, Dennis L. Zimmerman, December 2003.

We exercised the model by starting with a small retention limit, then raising it incrementally until the cost to retain the next unit or quantity becomes greater than the cost to dispose:

$$\text{If } ECR(N) > ECD(N) \text{ or } ECR(N) - ECD(N) > 0, \qquad \text{[Eq. 3]}$$

$$\text{then } s \cdot up \sum_{j=1}^{H} \frac{1 - F_N(j)}{(1+i)^j} - \left(-v \cdot up + \sum_{j=1}^{H} \frac{up \cdot f_N(j)}{(1+i)^j} \right) > 0, \qquad \text{[Eq. 4]}$$

$$\text{and } up \cdot \left[s \sum_{j=1}^{H} \frac{1 - F_N(j)}{(1+i)^j} + v - \sum_{j=1}^{H} \frac{f_N(j)}{(1+i)^j} \right] > 0. \qquad \text{[Eq. 5]}$$

Since the price *up* is never negative, and no other variable in Equation 5 is item-specific, the sign of the expression, and therefore the economic retention limit, is independent of the item cost. Therefore, we can determine the economic retention limit for a group of items using only their collective depletion probabilities.

What Are the Practices of the Military Services and DLA?

Each service has a different approach for determining economic retention limits (ERLs).

Defense Logistics Agency

DLA computes the economic retention level as six times the forecast annual demand *above* the approved acquisition objective, approximately 8 years of the demand total.

U.S. Army

The Army employs an ERL mathematical model that finds the point at which the increase in holding cost for retaining one additional unit of stock would exceed the loss in potential value from its disposal. The potential value of a unit of stock is influenced by an assumed probability of future obsolescence and a probability of loss or deterioration.

U.S. Navy

Current Navy retention policy depends on the status of the weapon system to which the item in question applies. Weapon systems are categorized as ascending, steady, or declining, depending on the state of the weapon system's life cycle. The policy applies a years-of-supply rule and a minimum floor rule, as shown in Table 1.

Table 1. Navy Retention Policy

Weapon system status	Retention limit (years of attrition demand)	Minimum retained (floor)
Ascending	12 years	5 each
Steady	8 years	3 each
Declining	4 years	1 each

U.S. AIR FORCE

The Air Force uses a multiple-step process to set its ERL.

- The gross retention level (GRL) is equal to nine times the forecasted annual demands, plus additive future requirements, war reserves, and foreign military sales requirements. The GRL is the maximum amount of serviceable stock the Air Force will retain.
- The minimum retention level (MRL) is similar, except it is based on 9 years of forecasted *condemnations*, as opposed to demands. The MRL is the minimum authorized for stock retention, and the maximum amount for unserviceable retention.
- After some adjustments (e.g., the GRL is adjusted to be at least as large as the MRL), the GRL and MRL are compared to assets on hand and the AAO to determine the ERL.

ANALYSIS OF DEMAND UNCERTAINTY

High Demand Variability Within the Department of Defense

Demand that DoD materiel managers see at the wholesale echelon is marked by high variability due to

- random equipment failures,
- retail bundling of customer demand into larger replenishment orders placed on the wholesale echelon, and
- the generally dynamic environment that military units perform in driving customer consumption.

Numerous studies have looked at DoD demand variability and ways to forecast it. The 2003 LMI study on retention by Zimmerman[8] looked at demand variance-to-mean ratios (VMRs) and compared them to the value of 1, which is assumed in many inventory models. Zimmerman found that many items had ratios well above 1. The overall average ratio was 32 for DLA items and 6 for Air Force items, both of which are much greater than a ratio of 1.[9]

Our analysis revealed high ratios as well, especially for DLA items. Table 2 shows VMRs for the different item groups we analyzed. For all groups, the average ratios are well above 1.

Table 2. Variance-to-Mean Ratios

Group	Average ratio	Median ratio
Army	71.8	2.4
Ships—1H COG	52.3	6.1
Ships—other	6.9	1.8
Naval aviation	30.3	2.4
DLA random sample	310.0	27.3

Another 2003 LMI study[10] on expected variance in DLA inventory models found that 14 to 15 percent of all items had demand that exceeded expected variance, and 36 to 40 percent of all items with demand had highly variable demand.[11]

The effect of high variability in demand is twofold: backordered customer demand and materiel above expected levels. The 2003 LMI study found that unexpected demand contributed to 12 to 13 percent of all backorders.[12]

In 2004, LMI studied actual DLA inventory levels versus planned levels.[13] We found that 8 percent of the items at the end of 2002 had levels below planned, and 4 percent had levels below planned at the end of 2003. More important to economic retention, we found that 68 percent of the items at the end of 2002 had levels above planned, and 72 percent had levels above planned at the end of 2003.[14]

[8] Op. cit., LMI Report LG301T1, December 2003.

[9] Ibid., LMI Report LG301T1, p. 5-2.

[10] LMI, *Sources and Impacts of Defense Logistics Agency's Unexpected Demand*, Report SVD10T3, Dennis L Zimmerman, July 2003.

[11] Ibid., LMI Report SVD10T3 p. iv.

[12] Ibid., LMI Report SVD10T3 p. iv.

[13] LMI, *DLA Aviation Items: Actual Inventory Levels Versus Planned Levels*, Report SVD10T6, Dennis L Zimmerman, October 2004.

[14] Ibid., LMI Report SVD10T6, p. 8.

Analyzing the Impact of High Demand Variability on Materiel Retention

Evaluating the costs associated with retaining or disposing of a quantity of an item requires some assumptions about the likelihood of future demand for that quantity. To study that likelihood and how it would impact materiel retention, we looked at stock depletion rates instead of traditional demand forecasts.

Traditional demand forecasts are not useful in this examination, as they cannot project far enough ahead. Moreover, the fact that an item has a surplus of stock today is testament to the risk associated with buying inventory, and suggests some fault with the demand forecast used for that purpose. Using that same forecasting tool to make a retain-or-dispose decision would be self-defeating.

Stock depletion rates give us the probability that a given quantity of stock will be used for each year in a future time horizon. In the absence of accurate long-term demand forecasts, this is sufficient for developing economic retention limits. For example, if we start with a group of items with inventory levels computed as 4 years of stock in some past year and replay actual demand history, we would see how many items had their stock depleted in 1 year, 2 years, etc. Dividing the total number of items into the number depleted each year gives us the probability that 4 years of stock for that group of items would be depleted that year. Such probabilities can then be used in the economic retention formula given in Equation 5.

LMI Analysis of Air Force Retention

LMI's Air Force analysis briefed to SCI in 2006 was built on the 1999 Bachman and Burleson study, which, in turn, built on the 1997 Kruse study. The Air Force sponsored the 2006 work in response to an audit by the Government Accountability Office, which found Air Force retention levels were not based on economics.

The 2006 study results were not significantly different than the results of the 1999 study. This showed that the recommended policy was relatively stable with regard to the risk of repurchase and the differences in risk between item groups with different levels of demand. Again, the results were driven by empirical stock depletion rates and their corollary: The longer an item goes without demand the less likely it will have demand.

That corollary was the basis for the no-demand option in the 2003 Zimmerman study and recommendation in our 2006 Air Force analysis that minimum levels be used for insurance and numeric stockage objective (i.e., no forecast) items.

REPEATING THE AIR FORCE ANALYSIS

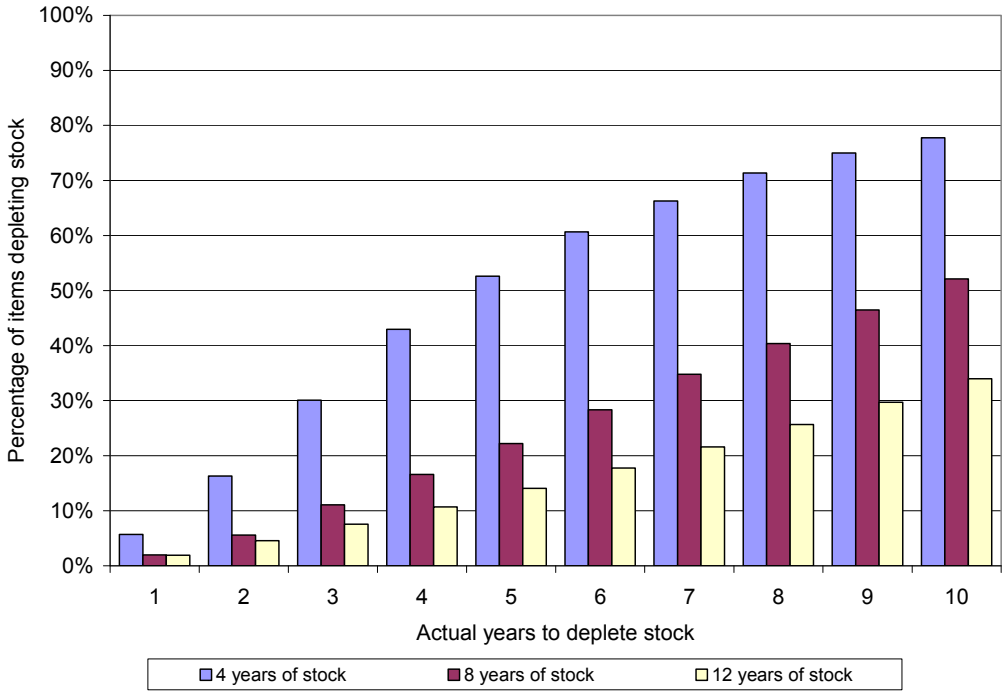
To develop the depletion rates as in the Air Force analysis, we analyzed long-term demand data for several different item groups and assessed the probability of depleting some given level of inventory. As previously noted, we began with a hypothetical quantity of stock equal to some multiple of the average annual demand rate, and then stepped through the subsequent demand periods (months or quarters, depending on available data), allowing each period's actual demand to deplete this posited inventory level. We continued this depletion process until all stock was depleted or we reached the end of the demand history. If all stock was depleted, we recorded the time depletion occurred. After processing all items in the data set, we calculated the percentage of items that deplete the starting quantity in each subsequent period. Those percentages formed depletion probability curves for varying levels of initial stock.

In what follows, we present the results for military service and DLA groups of items. The charts in Figures 1–9 show the actual number of years it took in our analysis to deplete a stock level equal to 4, 8, or 12 years of forecasted demand. That is, starting with either 4, 8, or 12 years of stock at a past point in time, the graphs show how much of that stock was depleted in the next 1 year, 2 years, etc.

DLA Random Sample

We analyzed five random samples of about 30,000 DLA items and found depletion rates as shown in Figure 1.

Figure 1. DLA Random Sample Depletion Rates



About 51 percent of the items depleted 8 years of stock in 10 years or less. In other words, if we had set a retention limit of 8 years and disposed of any stock above that level, then, in 51 percent of the cases, we would have had to repurchase by year 10 in order to support demand. Raising the retention limit to 12 years would still have lead to the repurchase of 33 percent of the items. All five random samples showed nearly identical depletion rates.

DLA Weapon System Groups

Because DoD policy allows for retention of items in a specific weapon system, we also developed depletion rates for DLA items with applications to several weapon systems.

The depletion rates differ among the weapon systems. Figures 2–5 show depletion rates for four of the weapon systems analyzed. The HEMTT (heavy expanded mobile tactical truck)vehicle has a much higher depletion rate than the random sample, which crosses all weapon and non-weapon categories. The F-16 aircraft and the Trident submarine show lower than average rates. The Kiowa helicopter has even lower rates. This suggests that DLA might consider a weapon system–based retention policy. Based on the rates shown here, the HEMTT should have a higher retention limit than the Kiowa, with the F-16 and Trident falling between the two.

Figure 2. DLA HEMTT Item Depletion Rates

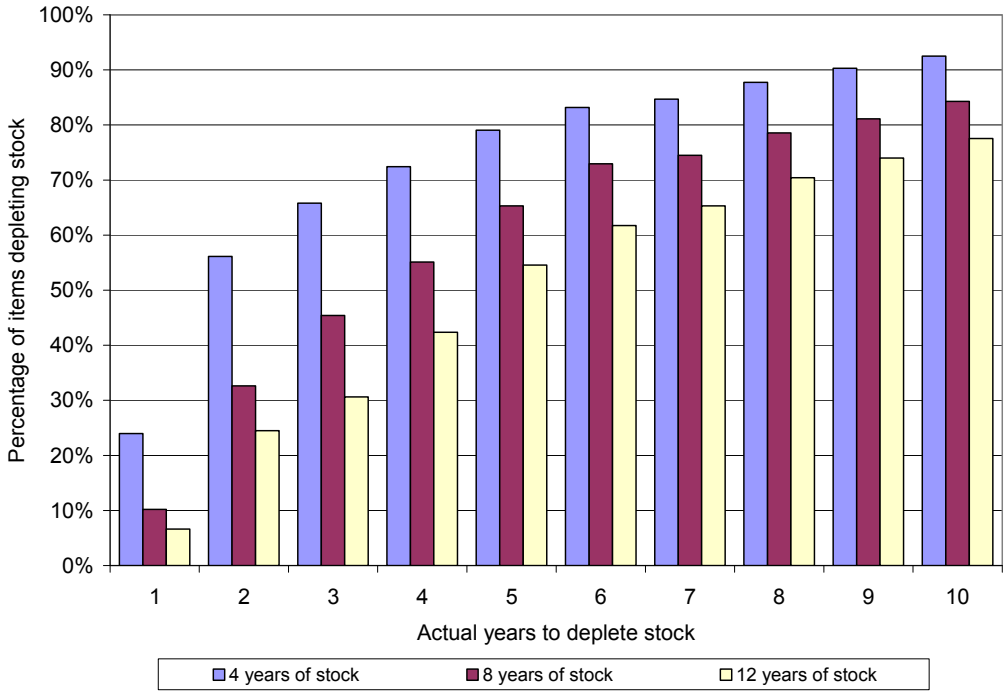


Figure 3. DLA F-16 Item Depletion Rates

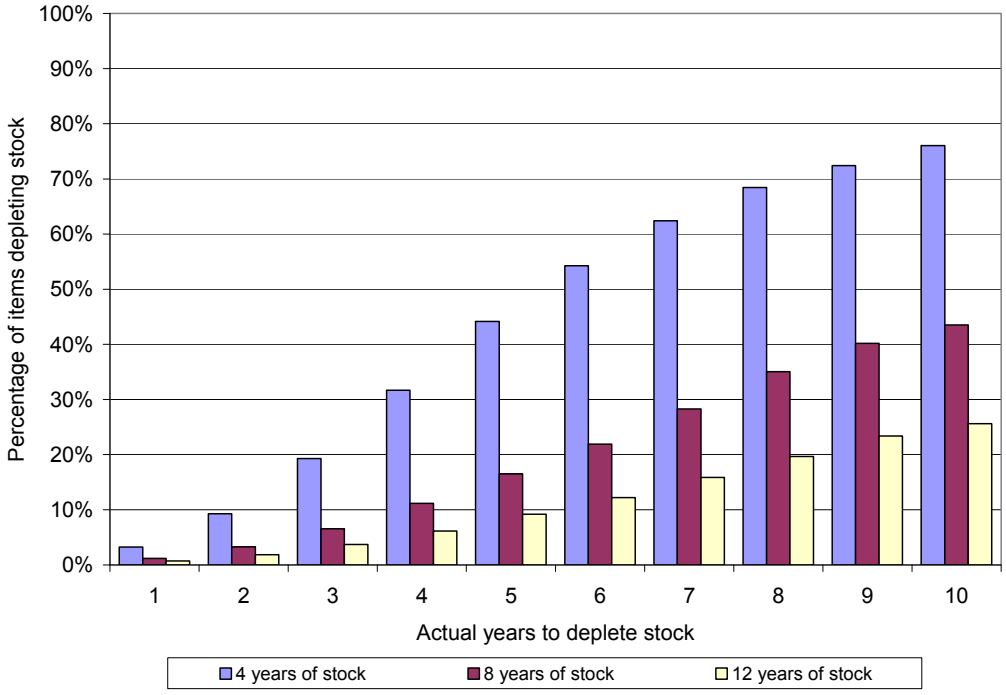


Figure 4. DLA Trident Item Depletion Rates

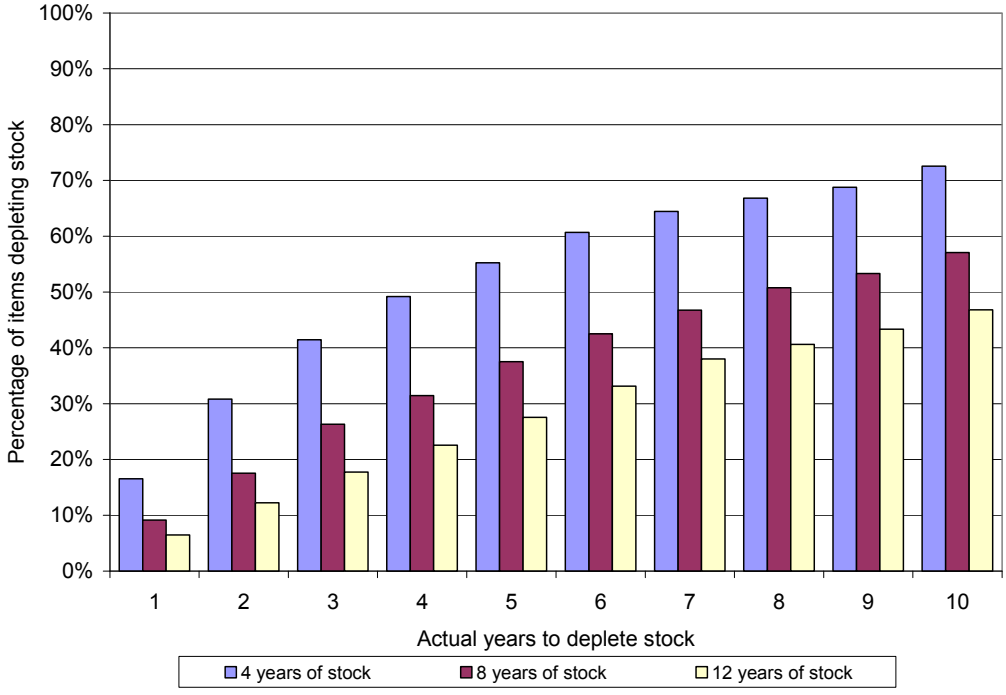
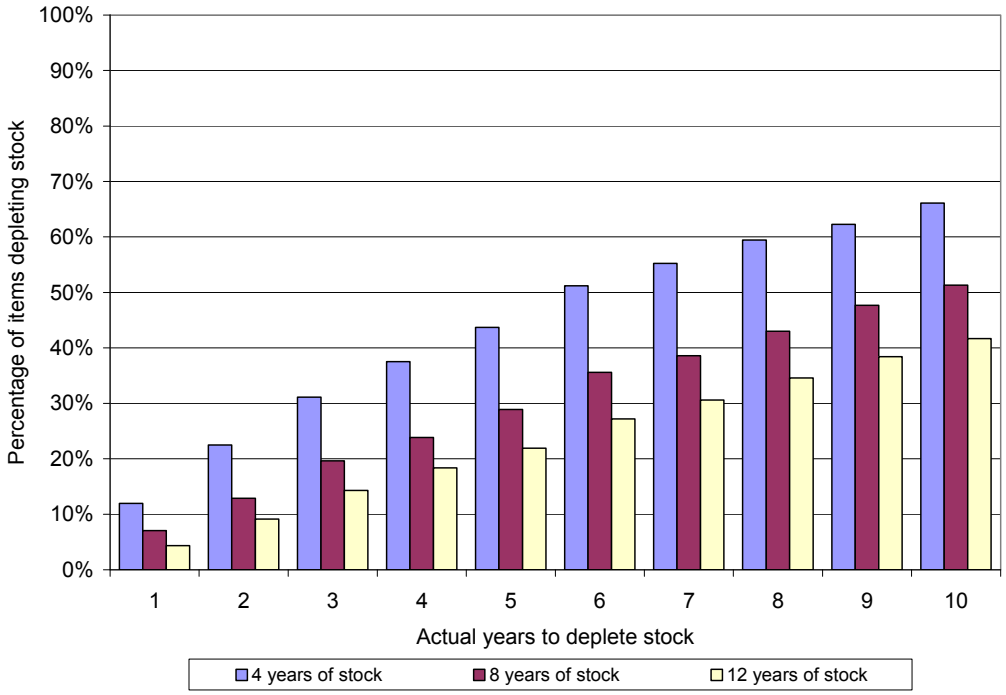


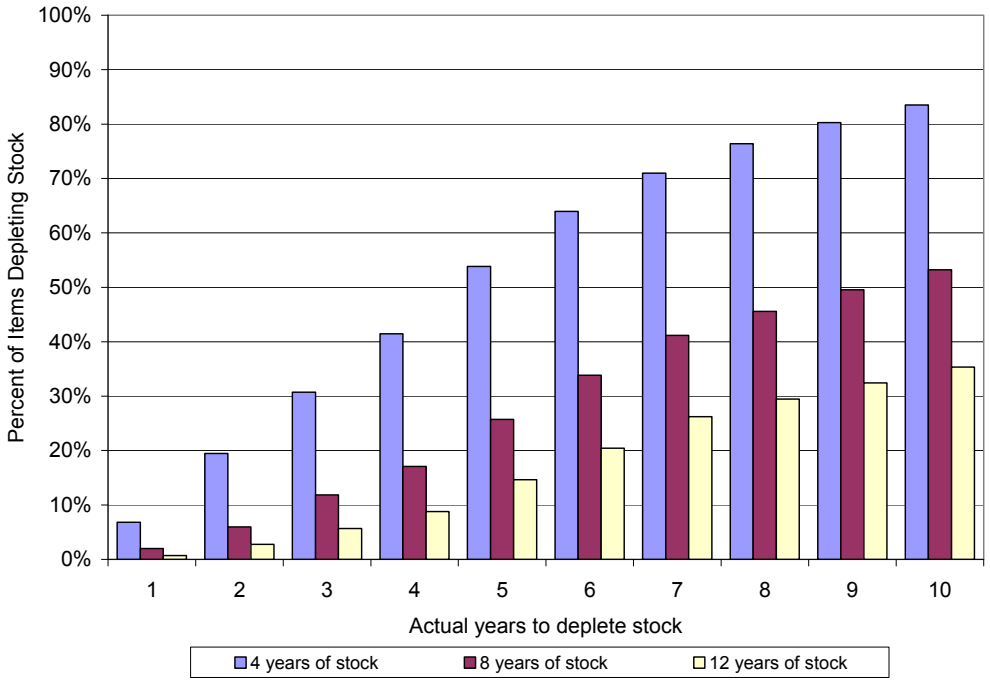
Figure 5. DLA Kiowa Item Depletion Rates



ARMY

For Army items (Figure 6), the depletion rates are similar to DLA's random sample. In both cases, about 52 percent of the items would deplete an 8-year level within 10 years. About 33 percent would deplete a 12-year level within 10 years.

Figure 6. Army Depletion Rates



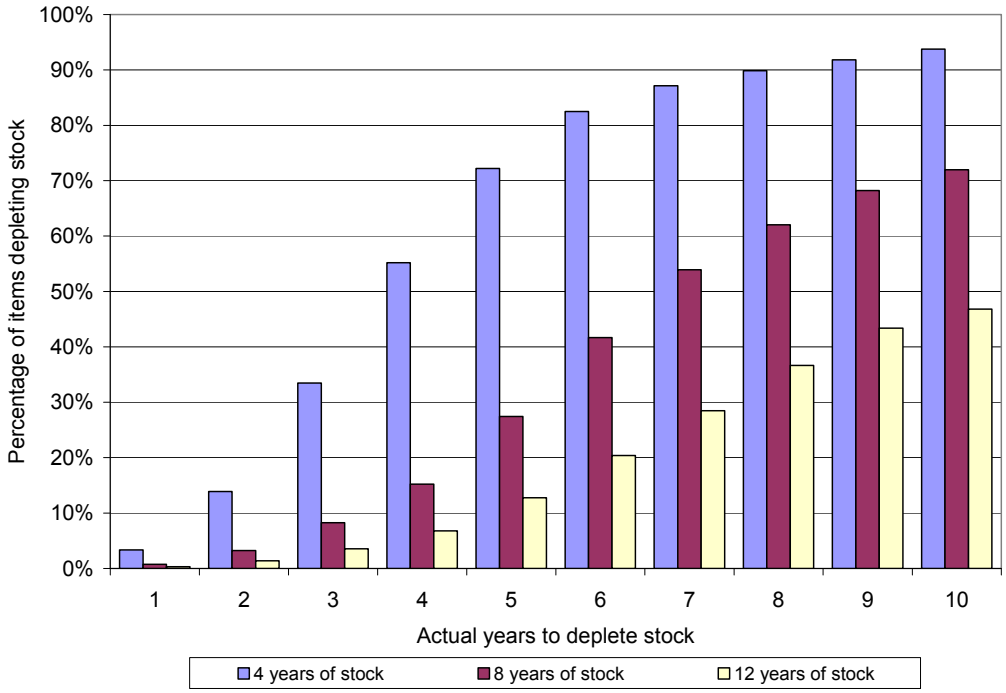
NAVY

Navy items were divided into three separate groups: aviation, consumable ship parts (identified as 1H COG), and reparable ship parts. In all three cases, we found similar depletion curves.

Naval Aviation

Naval aviation items show much more aggressive depletion rates than Army or DLA items. More than 70 percent of items would deplete 8 years of stock in 10 years or less, and about 47 percent of items would deplete 12 years of stock in that time. Figure 7 illustrates the naval aviation depletion rates.

Figure 7. Naval Aviation Item Depletion Rates

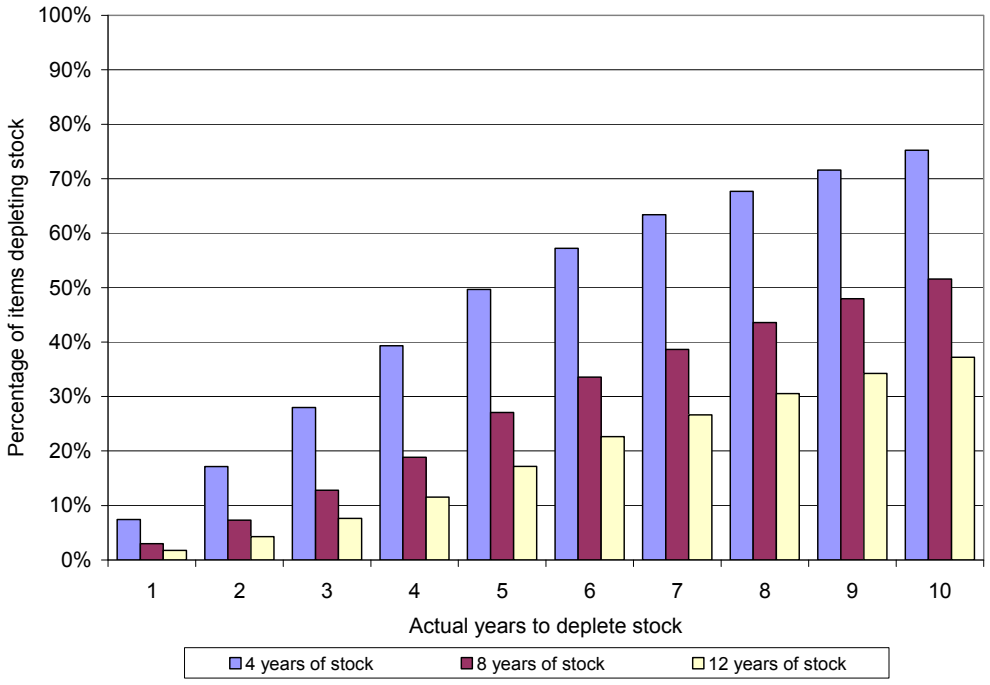


Navy Consumable Ship Parts

A significant portion of the consumable items managed by Naval Inventory Control Point, Mechanicsburg, are used by the Navy's Nuclear Reactor Program, and are treated differently with regard to retention and disposal. Therefore we treated them separately from other ships parts.

Depletion rates for these parts are lower than naval aviation, with an 8-year level being depleted within 10 years about 51 percent of the time, and a 12-year limit being depleted about 38 percent of the time. This would normally argue for lower retention limits than aviation items because of the lower risk of depletion. Figure 8 illustrates the depletion rates for consumable ship parts.

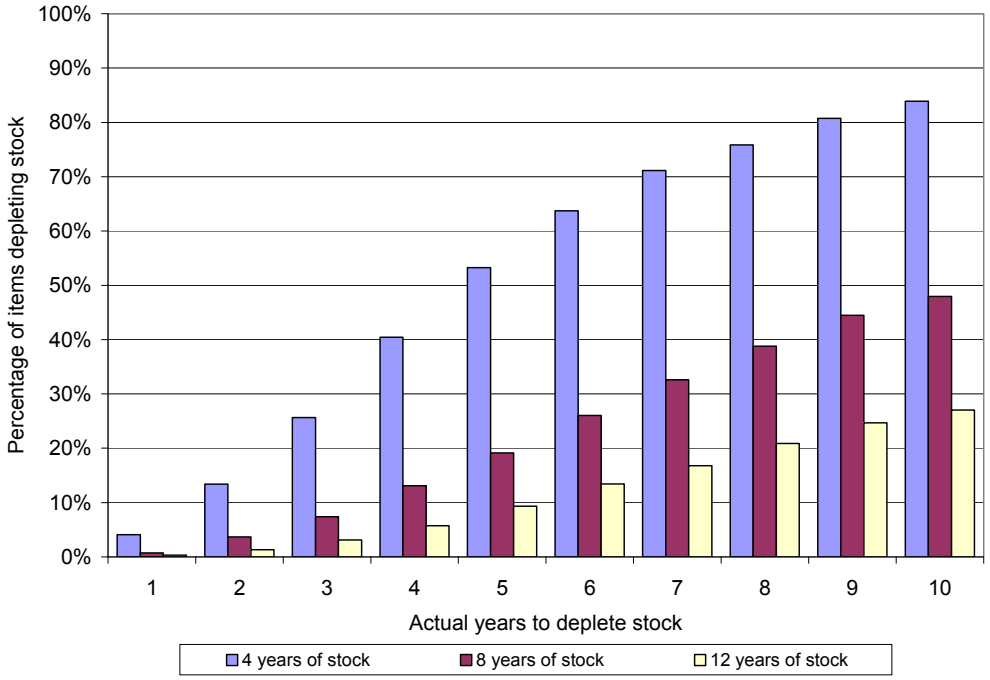
Figure 8. Navy Consumable Ships Parts (1H) Depletion Rates



Navy Reparable Ship Parts

Reparable ship parts show a pattern similar to the ships consumables, slightly higher for depletion of 4 years of stock, but lower for 8 and 12 years of stock. The lower depletion rates for the larger stock levels should result in slightly lower retention limits for these items compared to the other Navy groups. Figure 9 illustrates the depletion rates for reparable ship parts.

Figure 9. Navy Reparable Ships Parts Depletion Rates



IN SUMMARY

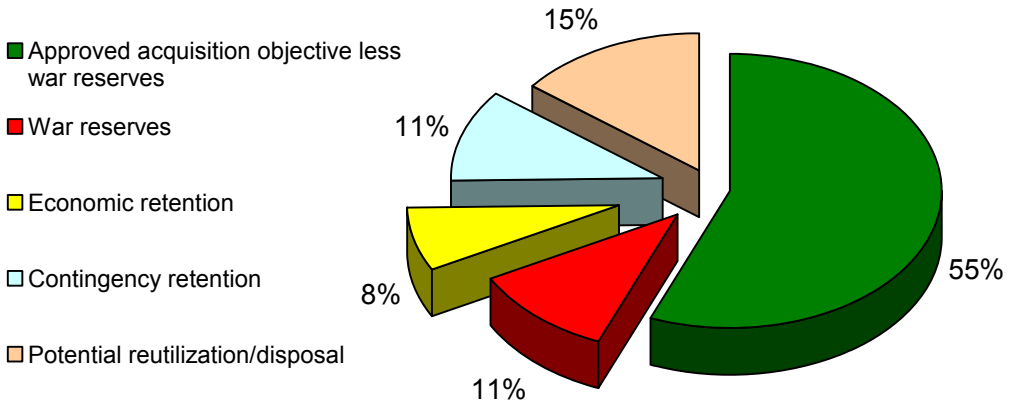
In general, the results for the other military services and DLA show the same levels of uncertainty as found in the Air Force analysis. Together they give proof to the fact that simple computations yielding years of stock for an item are not credible. A statement that an item has 20 years of stock or 50 years of stock is not only conjecture; it cannot be supported statistically.

STORAGE ANALYSIS OF ECONOMIC RETENTION

Economic Retention Stocks

Figure 10 shows the breakout (by dollar value) of the major inventory categories as of the end of 2006. Economic retention stocks are about 8 percent of the total. We lack the item-level stratification data required to show the distribution of storage cube for each of these categories, but it is not unreasonable to assume the two distributions are similar, and about 8 percent of the total cube is in economic retention. If so, this category has little potential for making significant reductions in the total occupied storage space.

Figure 10. Dollar Value Breakout of DoD Inventory



Optimal Retention Trading Off Storage and Repurchase Costs

Using the model and the probabilities developed above, we compared the cost of retaining versus disposing of the various item populations. Consistent with earlier studies, the risk associated with disposal and possible (in many cases *probable*) repurchase far outweigh any storage savings; and economic retention limits are generally greater than those used today. Table 3 shows the recommended ERLs for each DoD component, based on our model and each group's depletion rates. Most are in the range of 20 years of more.

Table 3. ERL Recommendations by Item Group

Group	Current policy	ERL (years)
DLA random sample	6 years above the AAO	24
Army	Variable	24[a]
Naval Aviation	4, 8 or 12 years above the AAO	25
Navy consumable ship parts	4, 8 or 12 years above the AAO	24
Navy reparable ship parts	4, 8 or 12 years above the AAO	19

[a] This does not suggest the Army should abandon its ERL model, but rather illustrates the general range for economic retention.

Reparable Versus Consumable Items

Reparable items lend an additional level of complexity to economic retention decision for these reasons:

- Whenever a demand is placed for a reparable item, it normally represents an exchange of a serviceable asset for an unserviceable asset. That is, the customer is demanding a serviceable asset to replace an unserviceable asset that he is returning for repair.[15] If the unserviceable reparable asset is disposed of and later needed, a future repurchase cost would be incurred. Consequently, attrition, not demand, drives the retention decision for reparable items.

- If the unserviceable asset is held and later needed to fill a demand, a repair cost would be incurred before it could be issued. So the repurchase cost for a reparable item is the difference between the replacement cost and the repair cost.

Lacking complete and specific information on condemnation rates, repair costs, and unserviceable assets, we did not address this issue in any detail in our analysis. We did, however, examine depletion rates for Army items using condemnations (i.e., demand times effective condemnation rate) and found the depletion rates were nearly identical to those for demand. For the most part, this was due to a very large percentage of the items with an unserviceable return rate of zero, causing the effective condemnation rate to be 100 percent.

Illustrating the Negative Impact of Using ERS to Achieve Space Reductions

Increasing the ERLs as shown above would keep inventory at higher levels, but it would also avoid a large cost of future repurchasing. For example, we compared DLA's current 8-year (approximate) retention limit to the proposed 24 years using actual on-hand data for a sample of 13,350 national stock numbers that have at least 8 years of stock on hand. Table 4 shows the results for a 10-year analysis discounted to present value. Over a 10-year period, the cost of repurchasing would be about half the value of disposals, far greater than the holding cost savings and the disposal revenue.

[15] Some demand for reparable items may occur with no unserviceable turn-in (e.g., a new provisioning demand or the unserviceable asset is condemned at the field level).

Table 4. Impact of 8- vs. 24-Year ERL (DLA)

Number of items	13,350
Value of inventory	$184.9 million
Total item cube	1.6 million cf
Value of disposals	$33.5 million (18% of total)
Cubic feet of disposals	207,000 cf (13% of total)
Storage cost if retained (10 years)	$141,000
Disposal revenue (at 5%)	$1,675
Repurchase cost (over 10 years)	$16.8 million (50% of disposal value)

Illustrating What Storage Cost Rates Are Needed to Justify Reducing ERS

As previously noted, the traditional rate assigned to storage cost is 1 percent of the value of the inventory. The cost of storage would need to be much higher to reduce ERLs. We found the rates in Table 5 using the economic retention model to see what the storage cost rates would need to be for each of our item groups.

Table 5. Storage Cost Rates for an 8-Year Retention Level

Group	Rate
Army	6.6%
Navy ships—consumable	6.2%
Navy ships—reparable	5.3%
Navy aviation	9.8%
DLA random group	6.0%
DLA Trident items	8.3%
DLA HEMTT items	19.7%
DLA Kiowa items	6.7%

CONCLUSIONS AND RECOMMENDATIONS

What Can Be Concluded

All the findings in this study and in all previous studies cited in this report lead to one clear conclusion: Reducing retention levels is not an economic answer to reducing storage cube.

The reason is simple. Repurchase costs far outweigh storage costs, even without assuming other factors, such as procurement sourcing problems, administrative costs to buy, and the fixed portion of holding cost. The risk of incurring repurchase

costs is such a dominant part of the retention-or-disposal question that we believe DoD should view it not as a retention limit, but as a deferred repurchase decision.

Absent specific knowledge of an item's future demand, the military services and DLA should manage the retention-versus-disposal issue by managing the risk associated with repurchasing materiel.

The conclusion and the findings in this study do not contradict the current policy in DoD 4140.1-R. In fact, they reaffirm the need for using economic analysis to set economic retention levels.

What We Recommend

Our recommendations are in two areas: recommendations that deal with economic retention policy and recommendations that deal with storage savings.

Revising Retention Policy

The overall policy for materiel retention in Section C2.8 of DoD 4140.1-R, *DoD Supply Chain Materiel Management Regulation*, correctly defines the economics of retention and the need to use economic analysis and up-to-date cost factors when deciding what to retain.

However, we recommend the requirements and procedures be revised as follows:

- Refocus the emphasis from a retention decision to a repurchase decision, given the main cost driver is the repurchase cost. For example, one change would be to change the section title from "Materiel Retention" to "Materiel Retention and Repurchase."
- Call for the military services and DLA to track retention and repurchase metrics. Specifically, each should have metrics that track the following:
  - Repurchases of materiel previously sent to disposal. Such metrics would allow components to monitor their performance on the repurchase decision to ensure the components are not overly aggressive in disposing of stock.
  - Years of no demands for items in stock. Such metrics would allow components to monitor the stocks they are retaining to ensure they are not overly aggressive in retaining stocks.

- Include under procedures additional techniques for more accurately determining the probability of future demand or repurchase. An example would be engineering inquires to see if an item with no recent demand history is still part of a weapon system configuration. Such procedures are paramount to the disposal or repurchase decision because the probability of future demand or repurchase is the basis for the application of repurchase costs, which is the main cost driver.

- Under procedures, link materiel retention or repurchase to item reduction. Items with extended periods of no demand should be candidates for item reduction; stocks for items being purged from the supply system should have no materiel retention as they have no future repurchase risk.

ACHIEVING STORAGE SAVINGS

We recommend the Department not reduce economic retention limits to achieve storage savings; rather, it should seek alternative methods. The following are among potential strategies that warrant further investigation:

- Take a closer look at contingency retention stocks (CRS). This category consists of stocks above the economic retention limit that are held for certain contingencies. CRS has grown by 12 percent over the past year, and quadrupled in the past 8 years. CRS is now 40 percent larger than economic retention.

- More aggressively pursue disposal reviews and actions on stocks already classified as potential reutilization or disposal stocks (PRDS), focusing on the highest cube items. These stocks are above the economic retention limit and do not qualify for CRS. PRDS stocks, when re-priced at full acquisition cost, are more than double the value of economic retention stocks.

- Shift high cube items to direct vendor delivery (DVD). Taking high cube items out of the DoD depot system will achieve the requisite storage space reductions. This must be approached carefully to ensure customer support and any required surge capability can be maintained and increased DVD costs do not offset storage cost savings.

- Accelerate efforts to link wholesale and retail inventory levels via multiechelon modeling. Although retail and wholesale stocks collocated at a depot may appear "duplicative," only sound multiechelon modeling can determine the appropriate levels. Previous studies estimate this can save as much as 10 percent of the inventory value.

- Building on the BRAC analysis, define the specific support roles of strategic distribution platforms and forward distribution points to maximize space utilization while limiting duplicative stock locations, particularly for slow moving items.

- Augment traditional demand forecast accuracy metrics with a measure of bias to identify the potential for over-forecasting, and adjust forecasting methods accordingly. Most forecast accuracy metrics commonly in use are based on the absolute value of the forecast error (i.e., they ignore the + or − signs). Some forecast methods, however, have a tendency for positive bias; that is, the forecasts are too high more often than they are too low. This tendency leads to inflated inventory levels, and is especially dangerous for low-demand items with less potential to sell off the extra stock.

APPENDIX ABBREVIATIONS

AAO	approved acquisition objective
ADUSD	Assistant Deputy Under Secretary of Defense
BRAC	Base Realignment and Closure
CRS	contingency retention stocks
DLA	Defense Logistics Agency
DRMS	Defense Reutilization and Marketing Service
DVD	direct vendor delivery
ERL	economic retention limits
ERS	economic retention stocks
GRL	gross retention level
HEMTT	heavy expanded mobile tactical truck
MRL	minimum retention level
PRDS	potential reutilization or disposal stocks
SCI	Supply Chain Integration
VMR	variance-to-mean ratio

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14. ABSTRACT

Uncertainties in demand and lead-time make inventory investment a risky decision. Defense inventory managers carry safety stock to hedge against these uncertainties. Sophisticated mathematical models calculate the extent of risk and the cost of avoiding it, and size inventories accordingly. But the question of retaining or disposing of what appears to be surplus inventory also carries risk as it, too, is subject to demand uncertainties. Although disposals can reduce inventory levels and associated storage costs, they reap relatively little in terms of salvage value, and expose the inventory manager to a high risk of future demand and repurchase of the disposed parts. Retain/dispose decisions must consider long term demand probabilities, and cannot rely on the shorter term forecasts used for acquisition. Following the publication of earlier work in this area for Air Force reparable items, LMI was tasked to conduct similar analyses for the other components.

15. SUBJECT TERMS
Economic Retention; Retention; Disposal; Inventory Savings; ERL; Economic Retention Limit; ERS; Economic Retention Stock; Materiel Retention; Inventory Risk

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