An enterprise-wide continuous process improvement framework makes it possible for various cross-functional efforts linked together through a governance structure to create synergy.

contemporary issues

ACS: A Royal Australian Air Force Perspective
AFSO21: A Case Study in Process Improvement
DLA Forward Stocking: An Economic Analysis

Contemporary Issues in this edition presents three articles: "ACS: A Royal Australian Air Force Perspective," "AFSO21: A Case Study in Process Improvement," and "DLA Forward Stocking: An Economic Analysis."

In "ACS: A Royal Australian Air Force Perspective" Wing Commander Scott Winchester, RAAF, makes the case that continuing to further improve ACS interoperability between the USAF and RAAF is in the interest of both air forces, with ACS being a fundamental enabler of air operations. The more interoperable ACS capabilities are regardless of whether the USAF or RAAF is the lead or contributing air force in a coalition, the more responsive and agile the combat support arrangements available to support the warfighter. The USAF and RAAF share a high level of commonality regarding ACS principles, with flexibility, adaptability, and scalability being critical factors of how we provide combat support.

Master Sergeant Kimberly A Fiato, USAF, in "AFSO21: A Case Study in Process Improvement" provides a comparative analysis of AFS021 with private sector continuous process improvement (CPI) concepts. The article begins with an external environment analysis which provides a foundation from which to identify external forces driving Air Force transformation and continuous improvement efforts. Next, a content review of Air Force doctrine and CPI case studies provides a frame of reference for a comparative analysis. Finally, the article concludes by summarizing the CPI similarities and differences among various private sector industries.

Previous research has investigated the feasibility of forward stocking relatively expensive, Air Force-managed parts and concluded that forward stocking was not economical. Currently, DLA only forward stocks an item if it has four-or-more demands in a year. The criteria's intent is to ensure only high-use items are stored in-theater. In "DLA Forward Stocking: An Economic Analysis" the authors expand on previous efforts by considering the feasibility of forward stocking inexpensive, DLA-managed parts according to current DLA criteria, and additional criteria developed through the research. A general methodology is presented to model and evaluate the performance of forward stocking. Although the methodology is applicable to any potential theater, only United States Air Force Central Command with storage at Defense Distribution Depot Kuwait, is considered in detail.

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DLA Forward Stocking: An Economic Analysis

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Introduction

The Defense Logistics Agency (DLA) supplies Air Force units in the area of responsibility (AOR) with relatively inexpensive, consumable items. The DLA-managed items originate in the continental United States (CONUS), where they are stored and shipped directly to the forward bases in the AOR. DLA recently proposed forward stocking, in which items are stored centrally in-theater and then shipped to the AOR bases. Theoretically, forward stocking items should reduce transportation times from the DLA (forward) depot to the forward units. Additionally, forward stocking utilizes less expensive modes of transportation from CONUS to the forward DLA depot.

Previous research has investigated the feasibility of forward stocking relatively expensive, Air Force-managed parts and concluded that forward stocking was not economical.[1] Currently, DLA only forward stocks an item if it has four-or-more demands in a year.[2] The criteria's intent is to ensure only high-use items are stored in-theater. This research extends previous efforts by considering the feasibility to forward stock inexpensive, DLA-managed parts according to current DLA criteria, and additional criteria developed through the research. A general methodology is presented to model and evaluate the performance of forward stocking. Although the methodology is applicable to any potential theater, only United States Air Force Central Command (USCENTAF) with storage at Defense Distribution Depot Kuwait (DDKS), is considered in detail.

Research Methodology

A mathematical model was constructed for direct shipping from CONUS to the base, and for shipping to a forward stocking location, and then to the base. Figure 1 depicts the structure of this model.

The model, implemented in Visual Basic, computes the inventory pipeline and transportation costs for each item from CONUS either direct to the air base, or to forward storage and then to the forward base. Inputs to the model are the transportation costs and times of each route, along with the item's cost and daily demand rate. It is important to note the characteristics of direct shipping versus forward stocking. Items traveling directly use faster modes of transportation, such as airlift or commercial carriers; therefore, the pipeline time is shorter, and there is less inventory in the pipeline. On the other hand, items forward stored will travel to the forward storage location via less expensive transportation modes (such as cargo ships), and from forward storage to the base via ground convoys or intratheater airlift. These slower but less expensive modes of transportation increase ship time and therefore may require more pipeline inventory. (See Table 1)

Given ample lead time, any item can be economical to forward stock, since the accumulated savings from lower annual costs

Article Acronyms

AOR – Area of Responsibility
CAF LSC – Combat Air Forces Logistics Support Center
CENTAF – United States Air Force Central Command
CONUS – Continental United States
DDKS – Defense Distribution Depot Kuwait, Southwest Asia
DLA – Defense Logistics Agency
O&ST – Order and Ship Time
ROP – Reorder Point
SBSS – Standard Base Supply System
USTRANSCOM – United States Transportation Command

	Direct Route	Forward Storage Route
Modes of Transport	More expensive but faster	Less expensive but slower
Pipeline Inventory	Less	More
Safety Level Inventory	Less	More

Table 1. Direct Versus Forward Storage: Inventory Levels and Transportation Modes

Route	Cost ($/Shipment)	Time (Days)
CONUS Base (Direct)	37	11
CONUS Forward Storage	5	30
Forward Storage Base	20	15

Table 2. Pipeline Costs and Time

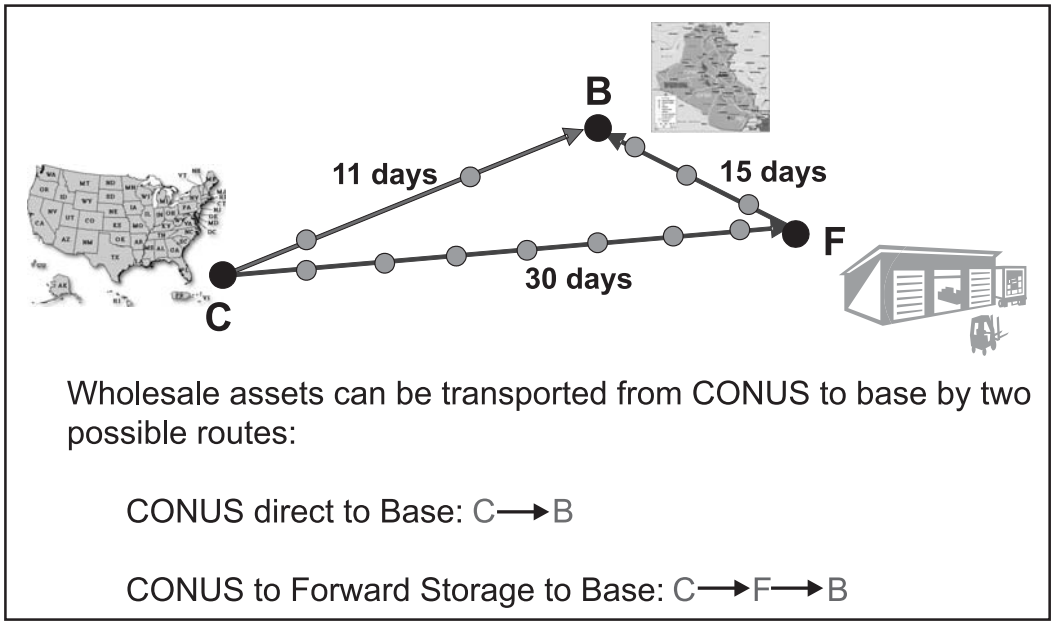

Figure 1. Forward Stocking Model

will eventually break even with and then exceed the one-time investment costs. Forward stocking is considered cost beneficial if the breakeven occurs in less than 5 years (in accordance with Air Force Manual 23-110). Therefore, the model evaluates economic feasibility by computing the breakeven time and the resulting savings or cost over a 5-year period.

Definite data was not available for the shipping costs and times; therefore, they were estimated for each leg of the direct and forward route. The pipeline times from CONUS to the base (days) were extracted from the AOR bases' SBSS routing identifier record. The CONUS to forward storage times estimated were derived from analysis of United States Transportation Command (USTRANSCOM) data. The forward storage to base times were derived from USTRANSCOM-provided pipeline performance based on shipment time from the US Army Material Command. Sensitivity analysis was also conducted with varied pipeline times. Transportation costs were based on AFMAN 23-110, chapter 19. Transportation costs and times are shown in Table 2.

The model optimally decides if an item is feasible to forward stock and computes the associated 5-year cost or savings. The optimal model, in turn, enables the development of easier-to-use rules of thumb to select what items to forward stock given a measure to evaluate performance.

Measuring the Performance of a Stockage Criteria

The objective is to develop criteria that identify items that are economical to forward stock. More specifically, the rule should not be one that stocks the highest percentage of items correctly, but one that selects items resulting in the greatest cost benefit. A set of criteria could potentially classify more items correctly than another, but ultimately result in more expense because the mistakes it makes are more expensive. Savings result when an economic item is forward stocked. Savings are the amount of money saved beyond the break-even point over a 5-year period. Likewise, extra expense is incurred when an uneconomical item is forward stocked. The expense is the amount of money by which the savings fall short of the break-even point over a 5-year period.

For a particular item and criteria, there are four possible outcomes (refer to Figure 2). The first outcome is that the item is *economical* and forward stocked. This is a correct decision resulting in savings.

The second outcome is that the item is economical but not forward stocked. This is called alpha-error and the potential savings from forward stocking the item is lost.

Next, an uneconomical item can be forward stocked, resulting in beta-error and extra expense.

Finally, an uneconomical item that is *correctly* not forward stocked has no effect on savings or expense. We seek a rule that minimizes incorrect decisions (alpha and beta error). However, beta error actually incurs costs (as opposed to a lost opportunity for savings), so it is considered the more egregious error.

Proposed Criteria

Recall that DLA currently uses a demand-only criterion of four-or-more demands in a year. The following modified criteria were developed:

Forward Stock If: Unit Price < Some Threshold -and- Demand ⩾ Some Threshold

The modified criteria ensure that items forward stocked are not only high demand but inexpensive, thereby eliminating excessive pipeline inventory costs. Possession of a model, performance measures, and prospective criteria is not sufficient to conduct an analysis. A list of the items demanded in-theater is also required. DLA views theater-wide demand levels; that is, aggregate demand from a number of bases in the theater. Although actual DLA data indicating demand levels were not available, three representative aggregate pipeline inventory levels were constructed for USCENTAF. The first combined demands from five USCENTAF bases: Al Dhafra, Ali Al Salem, Al Udeid, Baghram, and Balad, and represented combined Middle Eastern theater demands. The second consisted of items not currently forward stocked because of insufficient storage space. The third dataset consisted of items currently forward stocked. In summary, the process is as follows for a particular dataset:

- Select cost and demand thresholds
- Compute whether each item is economically feasible to forward stock with cost and demand threshold
- Compare simple rule performance to optimal performance
- Evaluate performance

Results

Analysis was conducted on the combined USCENTAF demands, items currently not forward stocked because of insufficient storage space, and items that are currently forward stocked. Several different sets of criteria are applied to the demand data, and their performance is discussed.

Combined USCENTAF Theater Demands

The combined USCENTAF demands consisted of 24,589 items at Al Dharfa, Ali Al Salem, Al Udeid, Baghram, and Balad as of 30 June 2006. The performance of the current DLA criterion (four-or-more demands in a year) is shown in Table 3.

The current DLA criteria would forward stock 2,483 (1,682+801) items (10 percent of the 24,589). Using this criteria results in a net loss of approximately $675K ($723K - $1.388M) over a 5-year period because of excessive pipeline inventory costs. (Note that the $688K is an opportunity cost and does not actually incur a monetary expenditure. Thus, it does not factor into the net savings or loss.) This is evident by the 801 items forward stocked that are not economical to stock (beta-error) and the associated cost of -$1.40M that overwhelms the transportation savings of $723K. The total net loss of $675K is over a 5-year period.

Now consider the addition of a cost criterion to DLA's demand criterion (Table 4). The best cost criterion was a cost of less than $50.

Adding a cost criterion prevents an excessive pipeline inventory of expensive items, eliminating virtually all the beta-error. This resulted in a net savings of $679K over a 5-year period. Additional savings is generated by lowering the demand criterion to two-or-more demands in a year (see Table 5).

Lowering the demand significantly lowered the alpha-error, capturing additional savings. The beta-error only slightly increased, and the total net savings was $955K over a 5-year period. This rule would stock 20 percent of the items demanded in the AOR, as compared to the 10 percent of items stocked under current DLA criteria.

Items Not Stocked Because of Insufficient Storage Space

Next, the modified cost and demand criterions are applied to the set of items not forward stocked because of insufficient storage space. A total of 15,819 items met the criteria for a demand level at the using air base, but were unable to be forward stocked at

	Forward Stocked	Not Forward Stocked
Economical	1,682 ($723K)	9,920 (-$688K)
Not Economical	801 (-$1.388M)	12,186
Total 5-Year Net Loss: -$675K		

Table 3. DLA Criterion Performance: Demands ⩾ 4/year

	Forward Stocked	Not Forward Stocked
Economical	1,646 ($709K)	9,956 (-$701K)
Not Economical	161 (-$30K)	12,826
Total 5-Year Net Savings: $679k		

Table 4. Performance: Cost < $50; Demands ⩾ 4/year

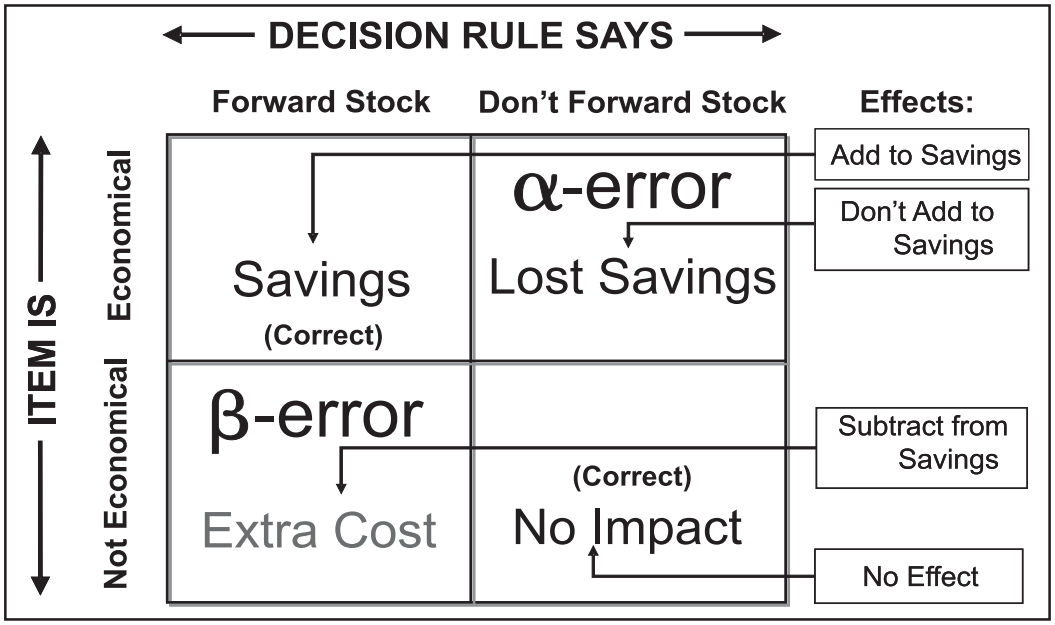

Figure 2. Performance Outcomes

the base because of insufficient storage space. Items that are economical to forward stock should be stored at the Defense Distribution Depot Kuwait (DDKS), Southwest Asia until storage space is available at the forward bases. Items that are not economical should not be stored at DDKS but should remain in CONUS.

Applying the modified cost and demand criterions to the items yields a potential savings of $747K (see Table 6).

A total of 3,026 items (19 percent) met the criteria to forward stock, of which 2,780 are economical. A total net savings of $747K results over a 5-year period. Savings can be increased if pipeline times are reduced. Table 7 shows the performance if the time from DDKS to the forward base is lowered to 5 days.

	Forward Stocked	Not Forward Stocked
Economical	4,510 ($1.026M)	7,092 (-$384K)
Not Economical	507 (-$71K)	12,480
Total 5-Year Net Savings: $955K		

Table 5. Performance: Cost < $50; Demands ≥ 2/year

	Forward Stocked	Not Forward Stocked
Economical	2,780 ($774K)	5,341 (-$286K)
Not Economical	246 (-$27K)	7,452
Total 5-Year Net Savings: $747k		

Table 6. Performance: Cost < $50; Demands ≥ 2/year

	Forward Stocked	Not Forward Stocked
Economical	2,861 ($843K)	6,448 (-$337K)
Not Economical	145 (-$11K)	6,345
Total 5-Year Net Savings: $832K		

Table 7. Performance: Cost < $50; Demands ≥ 2/year (DDKS to Forward Base = 5 Days)

Forward Leg (Days)	Direct Leg (Days)	Cost Difference
1	11	**-$2.6M**
3	11	**-$2.1M**
5	11	**-$1.5M**
7	11	**-$1.1M**
9	11	**-$481K**
11	11	**$0.0K**
13	11	**$357K**
15	11	**$747K**

Table 8. O&ST Cost Differences (Items Not Forward Stocked)

Forward Leg (Days)	Direct Leg (Days)	Cost Difference
1	11	-$21K
3	11	-$16K
5	11	-$12K
7	11	-$8K
9	11	-$4K
11	11	$0K
13	11	$4K
15	11	$7K

Table 9. O&ST Cost Differences (Items Currently Stocked at Forward Bases)

Although the same amount of items is forward stocked, more items are economical with a shorter pipeline from DDKS. Savings are increased by approximately $85K ($832K - $747K) over a 5-year period. Furthermore, stocking at DDKS is beneficial for all items not stocked at the using base, if the total pipeline time is less than the pipeline time direct from CONUS to the base. Since these items are not stocked at the using base, any pipeline time less than CONUS will reduce back order time. As space becomes available, economical items can be selected for storage at the using base.

Standard Base Supply System (SBSS) demand levels must be adjusted if forward stocked items have different order and ship times (O&ST) than items from CONUS. In the event of reduced forward pipeline times, the reorder point (ROP) can be lowered for forward stocked items yielding a one-time savings. The resulting savings or costs associated with different forward pipeline times were computed assuming all 15,819 items were forward stocked. The results are listed in Table 8.

Therefore, if the forward pipeline is reduced to 5 days, there will be a one-time savings of $1.5M in reduced supply levels at using bases, in addition to the $832K saved over a 5-year period under the proposed cost and demand criteria.

Items Currently Stocked at Forward Bases

The final set of items consisted of those currently stocked at forward bases. Currently there are 566 items stocked at the using bases, of which 529 are economical to forward stock. If the ship time from DDKS is reduced to 5 days, 537 items would be economical. SBSS demand levels would also require adjustments to their ROP levels yielding one-time savings. The cost differences for various forward O&STs are listed in Table 9.

If ship time from DDKS is reduced to 5 days, a one-time savings of $12K would be realized.

The Combat Air Force Logistical Support Center identified both the need to reduce the DLA-depot-to-using-base times, and the need to track assets shipped from the forward depot, especially shipments for mission capable requirements. Without adequate tracking, delayed and lost shipments occur which create workload delay, replenishment times, and potentially generate excesses, as other orders are placed to compensate for delayed shipments.

There is a *regional stock* alternative. For example, items can be stocked at DDKS without stocking at using bases. Although this would reduce inventory levels at the using bases, it would increase back orders because of the added ship time from the DDKS to the using base. Therefore, this alternative is not recommended.

Throughout the analysis, it was assumed additional inventory storage costs are not incurred. Applying the recommended forward stocking criteria still results in savings, albeit at a lower amount. Savings under DLA covered-storage costs is maximized by lowering the cost criterion to $20. Increasing CONUS-to-DDKS ship time to 60 days also results in a lower savings with an optimal cost criterion of $16.

Conclusion

Prepositioning supplies used by forward airbases at a forward storage location in the AOR is a viable alternative to the current practice of shipping items directly from CONUS. An item is economically feasible to forward stock if the annual savings realized by reduced shipping costs exceeds the increased one-

time, inventory investment costs within a 5-year period. Performance of both the current DLA demand criterion and the new criteria using cost were evaluated using three different data sets:

- All items with demands in the Middle Eastern theater
- Items not currently forward stocked because of limited storage space, and
- Items currently stocked at using bases

The current DLA criteria results in excessive costs by forward stocking uneconomical items. By adding a unit-price threshold and lowering the demand threshold, about 20 percent of the items used in the AOR are economical to forward stock and would achieve a $747K, 5-year savings. A sensitivity analysis conducted by varying the CONUS-to-forward-storage and forward-storage-to-base legs indicates that savings are reduced as pipeline times increase. Forward storage can be attractive from a strictly Air Force perspective, by creating a one-time savings through lowered base levels (vice the DoD perspective that incurs increased pipeline inventory). However, the total pipeline time of the forward-storage-to-base legs must be lower than that of the direct leg, to achieve lower base levels. Finally, although the primary focus of this study addresses the economic benefits of forward stocking, the operational ramifications of forward stocking must also be considered prior to implementation.

End Notes

1. Dianna Smith, *Determine Feasibility and Criteria for Forward Stocking Air Force-Managed Items at Defense Logistics Agency Depots*. AFLMA Final Report Number LR200520800, Air Force Logistics Management Agency, Maxwell Air Force Base, Gunter Annex, Alabama, May 2006.
2. Jackie Noble, "Adventures With the DDC-Building a Depot; The Magnificent Seven Make DDC History," *DDC News*, Winter 2004.

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