Locating and Consolidating Strategic Inventory

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ABSTRACT

The forward positioning of strategic inventory in the supply chain impacts transportation time and is important for sensitive demand. Consolidation of stocks creates pooling effects and minimizes costs. This study analyzes current military practice where forward consolidation of equipment is considered using optimization, and payback periods are calculated for the cost of consolidating inventory at a single location. Results indicate that forward positioning and consolidation reduces time and cost, and also creates savings in reverse logistics flows. The study has implications for geographically diverse supply chains such as humanitarian aid and emergency response operations.

INTRODUCTION

The US Air Force manages a variety of Security Forces' equipment. This equipment is divided into several different Unit Tasking Codes (UTCs) packages which are assigned to over seventy bases throughout the USAF. As a result of this distributed architecture, inconsistencies in management of the assets often exist and the timeliness of their deployment is lacking. Additionally, there may be cost and time savings to be realized from the consolidation [2][4] of this equipment at one or more centralized locations at a forward position in the supply chain [1]. In a preliminary study of equipment located at twelve bases, [3], showed that transportation savings may be achieved in the consolidation of such equipment at one or more forward locations, and that the cost to initially consolidate the equipment could achieve a realistic payback period. However, this study did not study the larger set of all equipment in the US Air Force, nor did it analyze historical deployment package size or offsetting warehouse costs from such consolidation. Therefore, the formal problem statement for this study is "What are the advantages and disadvantages of consolidating all US Air Force Security Forces' equipment?" The overall objective of the study is to evaluate the possible consolidation of specific security equipment at a single location, on or near a predetermined Aerial Ports of Embarkation (APOE) forward positioned in the transportation pipeline. The study aims to provide insight regarding whether to move forward with consolidation.

METHODOLOGY

This study is limited to specific security UTCs (see Table 1 for original listing of included UTCs) currently positioned in the United States. Also, the potential set of consolidation points is limited to a single site from among a fixed set of alternatives (Charleston, Dover, Kelly, McChord, McGuire, or Travis Air Force Bases). The choice of potential consolidation points does not necessarily indicate the current capability of the locations to support the consolidation. At the outset of this effort, several discussions took place with the Air Force in order to determine the scope of the study. The decision was made to include cost (maintenance and transportation), and time (maintenance, inspection, transport) data as the key variables for the study. It was also decided that historical and current data on costs and time would have to be captured to complete the study. Therefore, a set of relevant questions was compiled and sent to Security Forces experts at Air Force bases around the country. Responses to the questions were collected in late 2009. After the data had been collected and reviewed it was evident from observation that significant variability existed in almost every category. This served to reinforce the Air Force's initial concern that management of these UTCs at the separate bases lacked standardization and consistency in reporting.

Table 1. AIR FORCE SECURITY EQUIPMENT UTCs

UTC Name	UTC Title
QFL1B	SFS AIR BASE DEFENSE SQUAD EQPM
QFL2B	SFS AIR BASE DEFENSE (S-1) HQS
QFL2C	SFS AIR BASE DEF (S-3) HQ EQUIP
QFL3B	SFS 50 CAL M2 MACHINE GUN TM EQPM
QFL3C	SFS MK-19 TEAM LOGISTIC DETAIL
QFL4B	SFS MIL WORKING DOG EQ SUPPORT
QFL2D	SFS AIR BASE DEF (S-3) HQ EQUIP
QFL1E	SFS AFSOC SP EQUIPMENT SUPPORT
QFL3E	SFS CATM UTC LOGDET
QFL3D	SFS NONLETHAL CAPABILITY SET
QFL2D	SFS TACTICAL AUTOMATION SENSOR
QFL1C	SFS ALL TERRAIN VEH CAPABIL SET
QFL1M	SFS AIR BASE DEFENSE PORT TOWER
QFL1J	SFS AIRBORNE EQUIPMENT (*820 SFG ONLY)
QFL3F	SFS FORCE PROTECTION AMMUNITION
QFL2K	SFS FP COMMAND & CONTROL EQUIP
QFL2J	SFS HQ ADVON EQUIPMENT (*820 SFG ONLY)
QFL1K	SFS ENGINEERING ASSISTANCE EQP
QFL2M	SFS FLIGHT HQ KIT
QFL1L	SFS FORCE PROTECTION LOGISTIC
QFL2E	SFS SQUADRON HQ KIT
QFL4C	SFS MILITARY WORKING DOG KENNEL EQ
QFL1F	SFS LIFE SUPPORT EQUIPMENT
QFL1G	SFS TACTICAL VEH MX EQUIPMENT
QFL1H	SFS TACTICAL MEDICAL TECH EQUIP
QFL2F	SFS MRAP VEHICLE KIT ACCESSORIES
QFL2G	SFS UA HMMWV VEHICLE KIT ACCESSORIES
QFL2H	SFS LMTV KIT ACCESSORIES

First, all UTCs should be palletized and ready for transport, though some bases reported that this was not the case. This potentially affects the square footage needed for storing the equipment as well as the time required to move it, since pallets would need to be obtained before any movement. Second, the frequency of and time required to complete equipment inspections and the personnel doing them were noticeably different from base to base. Third, the majority of bases lacked historical data regarding the number and cost of equipment deployments over the last five years. Since an accurate demand (deployment) history was not available, the Air Force developed a standard deployment package to serve as the unit of demand in model created for this study. According to subject matter experts, this package represents the essential equipment required to meet Air Force mission requirements in an overseas location. It is meant to be representative of the equipment necessary to support a base with no additional support from a host country or other military service. It is understood that this requirement would be both situation and location dependent. Table 2 outlines the standard deployment package.

Table 2. Standard Package for Deployment

Quantity – UTC	Quantity - UTC	Quantity - UTC
3 – QFL1C	1 – QFL2T	2 – QFL1L
1 – QFL1G	2 – QFL2S	18 – QFL2L
3 – QFL2M	1 – QFL4G	1 – QFL3E
1 – QFL2W	1 – QFL4B	6 – QFL3D
1 – QFL3F	1 – QFL2E	2 – QFL3C
6 – QFL1M	8 – QFL3B	

Transportation costs for the study were obtained utilizing the military's Surface Deployment and Distribution Command's (SDDC) Electronic Transportation Acquisition (ETA) on-line system. This system is used to provide real-time estimates of shipping cost on a daily basis throughout the AF and is considered to be the system of record for ground shipping costs in the Air Force. Since actual weights for each consolidated pallet were not available and actual timing of the movement may be well in the future, point in time estimates for moving a single aircraft pallet weighing 7500 pounds from origin to destination was utilized. Then a truckload cost assuming four individual aircraft pallets of 7500 pounds each per truck was calculated to arrive at the final shipping costs in the model. These costs can vary depending on when the shipment occurs, potential for a return shipment for the company, and total number of pallets being shipped.

Assumptions

Throughout this study several assumptions had to be made in order to determine the correct scope of the problem and to meet time and resource requirements. They are:

- All equipment UTCs are properly configured and meet requirements to be transported
- Demand for any equipment UTC is equally important as demand for any other; therefore no weighting or preference was given to one UTC over another

- Under the current policy, all UTCs deployed overseas from their current bases will also be redeployed to the original bases and a return transportation cost is relevant
- No consumption of UTCs or equipment occurs while deployed and therefore there is no reduction in transportation costs for the returned assets or replacement purchasing costs
- Any manning and support equipment used to inspect or maintain UTCs at the current locations is available to be transferred to one or more consolidation points
- Current warehousing space will be able to be obtained at the consolidation point
- No damage, loss or theft of any assets will occur during transportation
- Transportation costs are fixed and no "time-value-of-money", inflation, or other financial adjustments have been made; all costs are given based on 2009 dollars
- Proposed consolidation points will be at potential APOE where possible

Decision Models

Two separate analysis steps were conducted in this study. First, a single-site decision model built for this study was created using the linear programming capabilities of Microsoft Excel. Given the large number of cells required by the model, the Risk Solver platform from Frontline Systems was utilized to extend the capability of Excel. The model was created to determine which UTCs to theoretically ship from each of the bases to a single APOE in order to minimize the cost while tasking enough UTCs to create a standard package. The model was built by first entering a cost matrix including the one-way transportation cost for a 463L pallet from each of the bases to each of the six potential APOEs. Next, a matrix of the current inventory of UTCs held at each base was entered into the model. This data was collected from the current storage bases with the assistance of HQ AFSFC. Then a group of binary 'changing cells' were created to identify a feasible solution that would fill the requirements for a single package. These cells cannot task inventory that is not available in the inventory matrix, and they are multiplied by the cost matrix to identify a total cost of shipping the required pallets to the selected APOE. In the model, the cost to ship the pallets was also doubled to replicate the return of the pallets back to the original destination. The model's actual minimum cost solution is generated by solving the linear program using Excel's Solver Add-in. Finally, user inputs were added to the model to allow the input of the number of required packages and the desired APOE prior to solving the model. This tool will serve as a means to determine the best sourcing for tasked UTCs for the Air Force, but was not considered the best method for making consolidation decisions since the theoretical optimized solutions would greatly understate the costs currently incurred by the Air Force to ship a standard package.
The second step of the analysis included creating a baseline historical cost to ship a standard package to each of the potential consolidation points. This was done by capturing the actual shipping costs and supply locations for a standard package which was shipped by the Air Force base to Shaw AFB, South Carolina during 2009. Using these same sources of supply and shipping quantities the costs were recalculated to determine how much it would have cost to ship this standard package to each of the potential consolidation points, thereby creating a baseline cost for each consolidation point. For example, "Baseline Dover", is the cost to ship a package identical to the package sent to Shaw in the

2009 deployment from the same source locations to Dover AFB. In addition to the baseline solutions, the model was also used to generate the consolidation aspect of the study, where the spreadsheet was used to determine the one-time cost to ship the entire inventory to each of the APOE locations. A separate consolidation tab was created for each solution. For example, "Dover", is the tab which includes the one-time cost to ship the entire UTC inventory currently at the bases to Dover AFB for consolidation. In order to compare the total costs for each approach, a "Results" tab has also been created comparing each baseline solution to its corresponding consolidation solution.

Results and Analysis

The cost was calculated for assembling one standard deployment package at each of the six consolidation locations by shipping the necessary UTCs for a standard package from the bases sourced during the 2009 deployment to Shaw AFB. This is similar to current Air Force operations, although the Excel model used in the study could optimize which bases the UTCs should come from in order to minimize cost, which is not part of the current operating procedure. Additional research will show how much the costs could be reduced if the model was used for sourcing. Table 3 shows the transportation cost to ship a single package to each of the six potential consolidation points.

Table 3. Single-Site Package Shipping Cost

Charleston	$ 100,488
Dover	$ 118,921
Kelly	$ 106,340
McChord	$ 191,720
McGuire	$ 123,747
Travis	$ 164,896

The cost for a one-time move of the entire inventory of the Security Forces' UTCs was also calculated. This was done in the model by multiplying the shipping cost from the base to consolidation point by the total number of pallets being transported from each base and then summing the results. This cost represents the one-time transportation cost to consolidate the entire current inventory at a single location. The results for all six potential consolidation points are listed in Table 4.

Table 4. Single-Site One-Time Move Cost

Charleston	$ 496,240
Dover	$ 492,864
Kelly	$ 385,086
McChord	$ 656,781
McGuire	$ 500,628
Travis	$ 579,796

In Table 4, it can be seen that the cost to consolidate the UTC inventory at each of the six sites ranges from approximately $385K-$656. In general it can be seen that the cost to consolidate is about three and one half to four times what it currently costs to ship a single package out and back to the APOE from the twelve bases. To understand this relationship further, the results were further compared by determining a payback period for each APOE.

The cost of a one-time consolidation could be paid for over a period of time depending on the number of deployments and tasked UTCs that are expected in the near future. To understand this relationship, a "payback period" was calculated to understand how long it would take such a consolidation to pay for itself. For example, currently shipping a single package of UTCs to Charleston and back costs $100,488 from Table 3. The cost to do a one-time consolidation of all of the UTCs at Charleston costs $496,240 from Table 4. Therefore, if consolidation occurs at Charleston, $100,488 in transportation costs could be saved each time a package is tasked; therefore, the consolidation would pay for itself after 4.93 packages ($496,240/$100,488). Thus, if the Air Force expects to deploy a single package for each of the next five years, then the consolidation will pay for itself, however, since the demand for UTCs is unknown the exact payback period will only be determined by the number of packages. The payback period for each single base is calculated in Table 5.

Table 5. Single-Site Payback Period

	Single-Site Cost	Consolidation Cost	Payback Period (# packages)
Charleston	$ 100,488	$ 496,240	4.93
Dover	$ 118,921	$ 492,864	4.14
Kelly	$ 106,340	$ 385,086	3.62
McChord	$ 191,720	$ 656,781	3.42
McGuire	$ 123,747	$ 500,628	4.04
Travis	$ 164,896	$ 579,796	3.51

From Table 5, it can be seen that for the current east and west coast APOEs, an expected payback period of 3.42-4.93 packages can be expected.

As stated in the assumptions for the study, each potential consolidation point may not be able to provide storage in a single facility for all security equipment. In that case, one potential option is the construction of a new warehouse facility. There are several factors that must be included in a warehouse construction decision. For example, will the construction utilize 'low' or 'high' bay construction? Will the facility utilize racking and shelving to reduce floor space requirements? Is it necessary to store all equipment inside the warehouse? Cost estimates (Table 6) were made utilizing data provided by the DoD Cost Handbook (2009). Estimates utilize a mandated standard cost of new construction ($107) and then an applied 'area cost factor' to account for differences in cost based on geographic area. The cost factors are the same that would be used in the completion of a Military Construction (MILCON) request and are assumed to be accurate as of the time of publication. The square footage requirement were provided by the Air Force.

Table 6. New Warehouse Construction Estimates

Location	Standard Cost for New 'Low Bay' Construction	Area Cost Factor	Required Sq ft.	Total Low Bay
Charleston	$107.00	0.89	500000	$47,615,000.00
McGuire	$107.00	1.15	500000	$61,525,000.00
Dover	$107.00	1.08	500000	$57,780,000.00
Travis	$107.00	1.31	500000	$70,085,000.00
McChord	$107.00	1.16	500000	$62,060,000.00
Kelly	$107.00	0.94	500000	$50,290,000.00

With these estimates in hand, the research team then calculated the payback period with new construction cost included. Table 7 outlines these results. These costs are included as a reference point only. As mentioned previously, other cost factors must be determined before complete estimates can be provided. Once the actual requirements for a warehouse have been determined, these calculations can be updated and then included in a final decision analysis.

Table 7. Payback including New Warehouse Construction

	Baseline	Consolidation	TransPayback	Warehouse Cost	Combined Payback
Charleston	$ 100,488	$ 496,240	4.94	$47,615,000	478.78
Dover	$ 118,922	$ 492,864	4.14	$57,780,000	490.01
Kelly	$ 106,340	$ 385,086	3.62	$50,290,000	476.54
McChord	$ 191,720	$ 656,781	3.43	$62,060,000	327.13
McGuire	$ 123,747	$ 500,628	4.05	$61,525,000	501.23
Travis	$ 164,897	$ 579,796	3.52	$70,085,000	428.54

Managerial Analysis and Implications

Along with the cost savings discussed above, there are several additional benefits to consolidating equipment. While these expected benefits are difficult to quantify, they can be of significant importance in the management and readiness of the equipment. The first benefit is in the manpower and number of hours required to inspect, maintain, and prepare the UTCs for deployment. Currently, the bases involved in this study report a total of 3385 hours per month required to inspect, maintain, and prepare the UTCs. Based on the estimates from the Air Force, at a consolidated location these same tasks could be accomplished in 1127 hours. This is a combined savings of 2137 hours, or equivalently 1.03 man-years and translates into a cost savings of approximately $619,000 per year. Note that this savings, if accurate, is more than enough to pay for the entire costs of the consolidation at all possible points except McChord. Additionally, this savings would occur every year, thus, the benefits from consolidation would continue to accrue over time. The second benefit in the consolidation options is the reaction time involved in deployment of the UTCs. Currently, any UTC tasked requires a minimum of three days transit time, with an average of four, from the origin to the APOE after notification of a tasking. When consolidated, this transit time is most likely reduced to half a day or less. Upon return from a deployment, the equipment is in transit the same four days, delaying reconstitution of the UTC. Consolidation would reduce this time to .5 days as well, for a total savings of approximately 7 days. Finally, a third benefit in consolidation is standardization, both in inspection and in storage of equipment. As noted in the Assumptions, the bases surveyed during this study reported a wide range of inconsistency in equipment inspection. The primary purpose, and underlying assumption, of standard UTC packages is that each UTC will be the same regardless of where it comes from.

Conclusions

It is the recommendation of the study team that HQ AFSFC should implement consolidation of the Security Forces' UTCs. While there is an upfront cost associated with moving all the UTCs to a consolidation point(s), the payback period is less than five deployments, just in transportation savings, in almost every case which is relatively small. The manpower savings estimated would pay for any consolidation between one and two quarters. Also, an issue that needs to be considered, but is beyond the ability of this study to quantify, is that of the consequences of a natural disaster or terrorist activity at the consolidation point. There is some positive probability of costs associated with "putting all your eggs in one basket". However, the benefits achieved by consolidation, including savings in cost, manpower, and time and improvement in standardization and management of equipment, may outweigh the risks. It is important to note that several assumptions were made in order to conduct this study. Among these assumptions, was the issue of warehousing costs. Additional costs for warehouse construction, shown in Tables 6 and 7, are based on a worst-case scenario assuming no storage capabilities existed at any of the 6 potential consolidation sites. Therefore, new construction of a warehouse of 500,000 square feet may be needed at a consolidation point. While the probability of this is low, it had to be taken into account and can significantly impact the decision to consolidate.

References

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