

# LOCATION CONSOLIDATION OF MILITARY EQUIPMENT FOR DEPLOYMENT

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## ABSTRACT

This research studies the potential consolidation of security forces equipment, needed for wartime, at aerial ports in the US. Currently this equipment is stored by the US Air Force at 12 different locations around the country, and it is hypothesized that consolidation at one or more locations would result in significant operational cost savings. Optimization of data collected from the US Air Force is conducted, and results indicate the best consolidation locations at either one or two locations in the US. Additionally, a method is provided for determining the payback period for the initial cost of such a consolidation.

**Keywords:** Inventory, Optimization, Military, Transportation, Cost Analysis

## INTRODUCTION

The US Air Force at Randolph Air Force Base Texas is responsible for the management of a variety of Security Force's' War Readiness Material (WRM) equipment packages. This equipment is divided into several different Unit Tasking Codes (UTCs) and the packages are currently positioned at twelve air force bases in the US. As a result of this distributed architecture, inconsistencies in management of the assets often exist and the timeliness of their deployment to overseas locations is often lacking. Previous research has shown that inventory consolidation may create efficiencies and pooling effects [5,11] leading to decreased logistics costs. Similarly, studies of service-sensitive demand including deployable military equipment have shown their may be important cost and time savings realized from the consolidation of equipment at one or more sites [2,7,9]. One study, entitled, "Evaluation of the Recent Deployments of Expeditionary Medical Assets" highlights the advantages of consolidating WRM equipment prior to overseas shipments. Based on this evidence, Randolph AFB funded the Air Force Institute of Technology to conduct an independent analysis on the advantages and disadvantages of Security Forces' equipment consolidation in late 2008. The problem statement for this study is "What are the advantages and disadvantages of the US Air Force consolidating its Security Force's UTCs at one or more locations in the continental United States. This paper describes the objectives, methodology, results and conclusions of this study and future planned research in this area.

## Objective

The objective of this study is to evaluate the possible relocation of security force's equipment UTCs, at either a single location or dual locations, at or near predetermined Aerial Ports of Embarkation (APOEs) where US Air Force aircraft depart to overseas locations. The study aims to provide insight, including benefits and limitations, regarding whether to move forward with consolidation. A secondary objective of the study is to provide the Air Force with a decision model that can determine the minimum cost tasking of Security Force UTCs from the existing twelve bases during a deployment. This will still be useful if consolidation is not immediately implemented by the Air Force.

## METHODOLOGY

A set of relevant questions was compiled and sent to the Security Forces Squadrons at each of the twelve Air Force Bases for the study. Responses to the questions were collected from the period 1 February-30 March 2009. After the data had been collected and reviewed it was evident 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. First, all UTCs should be palletized 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 deploy 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 deployments over the last five years. Since an accurate demand (deployment) history was not available, the research team developed a standard deployment package to serve as the unit of demand in the study. According to US Air Force subject matter experts, this package represents the essential equipment UTCs required to stand up a small to medium size base overseas during a deployment. It is meant to be representative of the equipment necessary to support a base with no additional support from the Army, Navy or the host nation. This requirement would be both situation and location dependent.

UTC	Number	Description
QFE42	9	Equip for 13 personnel team
QFE4F	4	.50 Calibar
QFE4S	3	Leadership Support Equip
QFEBJ	1	MK-19, grenade launcher
QFEBR	5	Dog Team Equip
QFEBX	4	Sniper/Counter Sniper Equip
QFETS	8	TASS

Table 1. UTC Description

Finally, two assumptions had to be made regarding movement of UTCs to different locations in order to evaluate consolidation costs. One being that the transportation costs (Table 2), obtained from the Langley AFB and Wright-Patterson AFB Traffic Management Offices, are point-in-time estimates for moving a single aircraft pallet weighing 7500 pounds from origin to a destination Air Force Base in the US. These costs can vary appreciably depending on when the shipment occurs, potential for a return shipment for the transportation company, and total number of pallets being shipped. Second, in a two

location scenario, UTCs have to be allocated as evenly as possible among the two coasts, in a manner that minimizes the total cost of movement.

### Optimization Models

In order to find the optimal consolidation point, the solutions for a single site location were generated using optimization. The problem is a classic facility location problem [1,4,6] which is similar and related to the  $p$ -median problem [3,8,10]. In this study, the number of consolidation points ( $p$ ) was restricted to either one single location or two locations (East Coast and West Coast of the US). The single-site decision model built to generate solutions for this study was created using linear programming within Microsoft Excel. The model was created to determine which UTCs to ship from each of the current twelve bases to a single APOE consolidation point in order to minimize the cost while tasking enough UTCs to create a single standard package for deployment. The model was built by first entering a cost matrix including the one-way transportation cost for an aircraft pallet from each of the twelve bases to each of the six potential consolidation points, Table 2. Next, a matrix of the current inventory of UTCs held at each base was entered into the model. 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 shipping cost for the required pallets to the consolidation point. In the model, the cost to ship the pallets was doubled to replicate the return of the pallets back to the original destination after the overseas deployment.

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 selection of the number of required packages and the desired APOE prior to solving the model. The original Excel solution used to identify the current method for shipping UTCs from the twelve bases is referred to as “Baseline” in the Excel spreadsheet, and the consolidation solution for each APOE is saved in the spreadsheet as a separate tab. For example, “Baseline Dover”, is the minimum cost solution to ship a single package to Dover AFB from the twelve bases and then return the equipment to its origin. In addition to the baseline solutions, the model was also solved for the consolidation aspect of the study, where the model 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 equipment inventory currently at the twelve bases to Dover AFB for consolidation.

	Altus	Col'bus	G'Fellow	Keesler	Lack'd	Laugh'	Luke	Maxw'l	Rand'	Shep'd	Tynd'l	Vance
Charl'ston	1900	2100	1900	1200	1400	1400	2200	1400	1400	1400	1200	1500
Dover	2300	3693	2100	1500	1900	1900	2100	1900	1900	1900	1400	1900
Kelly	800	1200	800	1000	0	700	1300	1200	700	800	1200	900
McChord	2100	2100	2100	2200	2500	2200	1500	2200	2300	2100	2500	2200
McGuire	2500	1900	1400	1100	1400	1400	2100	1400	1400	1400	1400	1600
Travis	2400	2100	1900	1400	2100	1900	1100	2100	2000	1900	2100	1900

Table 2. Transportation Costs of a Single Aircraft Pallet

To create the two-site model, several modifications had to be made to the original spreadsheet model. First, two sets of ‘changing cells’, one for the east coast location and one for the west coast location, had to be created. Then the model's constraints had to be modified to ensure that the total inventory being

tasked to the east and west coast from each of the twelve bases does not exceed the total inventory located at the base. The baseline solutions for the model were solved similarly to the single-site model with one standard package tasked to be shipped to both the east and west coast. However, a problem was encountered and for two of the UTCs (QFE4F and QFEBJ) there was not enough inventory to complete two standard packages. Therefore, an assumption was made to give the east coast tasking priority and a full package was filled for the east coast and a reduced package, without those two UTCs, was filled for the west coast. Using these methods, a baseline and a consolidation solution were generated by Excel Solver for each feasible combination.

## **Assumptions**

Several assumptions were made in the model in order to determine the correct scope of the problem and to meet time and resource requirements. They are:

- All currently positioned Security Forces' UTCs are properly configured and meet the requirements to be deployed
- Demand for any one UTC is equally important as demand for any other UTC; therefore no weighting or preference was given to one UTC over another in the models created for the study
- Under the current policy, all UTCs deployed overseas from the twelve current bases will also be redeployed to the original bases and a return transportation costs is considered a relevant part of the analysis
- No consumption of UTCs or equipment occurs while deployed and therefore there is no reduction in transportation costs for the returned assets or any purchasing costs for replacement assets included in the study
- Any manning, manpower positions, 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 from the owning installation of any potential consolidation point, or land will be made available on the installation for the funded construction of a warehouse facility
- No damage, loss or theft of any assets will occur during transportation, or it is assumed to be covered by the insurance of the carrier
- Transportation costs are fixed and no "time-value-of-money", inflation, or other financial adjustments have been made to the analysis of the cost of future deployments in the study and all costs are given based on 2009 dollars

## **Limitations & Constraints**

This study is limited to specific Security Forces' UTCs (QFE42, QFE4F, QFE4S, QFEBJ, QFEBR, QFEBX, QFETS) currently positioned at 12 US Air Forces Bases controlled by Headquarters at Randolph AFB, Texas. Also, the potential set of consolidation points is limited to a single site (either Charleston, Dover, Kelly, McChord, McGuire, or Travis) or to two sites with one on the east coast and one on the west coast. The two site consolidation problem does not consider Kelly Texas, therefore, there are six combinations of east-west coast locations (Charleston/McChord, Dover/McChord, McGuire/McChord, Charleston/Travis, Dover/Travis, and McGuire/Travis).

## RESULTS

### Single-Site Consolidation

The cost was calculated for assembling one standard deployment package at each of the six consolidation locations by shipping the necessary UTCs from the twelve AETC bases. This cost was then doubled since any UTC shipping from a base would have to be returned to that base upon completion of the deployment. This is similar to the current operation where the UTCs are stored at each base, although the Excel model used in the study optimizes which bases the UTCs should come from in order to minimize cost, which is not part of the current operating procedure. Table 3 shows the minimum transportation cost to ship a single package to the six potential consolidation points.

Charleston	\$ 90,400.00
Dover	\$ 114,600.00
Kelly	\$ 17,800.00
McChord	\$ 129,600.00
McGuire	\$ 92,600.00
Travis	\$ 106,400.00

Table 3. Single-Site Package Shipping Cost

In Table 3, it can be observed that each location has a cost for shipping a single package in the range of \$90K-\$129K with the exception of Kelly. This is due to the fact that 23 out of the 34 pallets required for a single package are already positioned at nearby Lackland AFB; therefore it is dramatically less expensive to ship a single package from Kelly at this time. This point will be discussed further in the Conclusions section. The cost for a one-time move of the entire inventory of the Security Forces' UTCs located at the twelve bases to each of the consolidation locations 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 summing. The cost is the one-time transportation cost to consolidate the entire current inventory at a single location. The results are listed in Table 4.

Charleston	\$ 212,700.00
Dover	\$ 270,358.00
Kelly	\$ 103,700.00
McChord	\$ 301,800.00
McGuire	\$ 214,600.00
Travis	\$ 262,000.00

Table 4. Single-Site One-Time Move Cost

In Table 4, it can be seen that the cost to consolidate the equipment at each of the six sites ranges from approximately \$212K-\$302K with the exception of Kelly which is again dramatically less due to the 31 pallets of equipment already located at nearby Lackland AFB. In general it can be seen that the cost to consolidate at the other five bases is about double 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 overseas deployments and tasked UTCs that are expected by AETC 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 \$90,400 from Table 3. The cost to do a one-time consolidation of all of the UTCs at Charleston costs \$212,700 from Table 4. Therefore, if consolidation occurs at Charleston, \$90,400 in transportation costs could be saved each time a package is tasked; therefore, the consolidation would pay for itself after 2.3 packages ( $\$212,700/\$90,400$ ) are shipped overseas. Therefore, if the Air Force expects to deploy a single package for each of the next three 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 base is calculated in Table 5.

	Single-Site Cost	Consolidation Cost	Payback Period (# packages)
Charleston	\$ 90,400.00	\$ 212,700.00	2.35
Dover	\$ 114,600.00	\$ 270,358.00	2.36
Kelly	\$ 17,800.00	\$ 103,700.00	5.83
McChord	\$ 129,600.00	\$ 301,800.00	2.33
McGuire	\$ 92,600.00	\$ 214,600.00	2.32
Travis	\$ 106,400.00	\$ 262,000.00	2.46

Table 5. Single-Site Payback Period

From Table 5, it can be seen that for the current East and West Coast APOEs, an expected payback period of 2.32-2.46 packages can be expected. The results are significantly different for Kelly, since a large number of pallets are already located at nearby Lackland AFB. Assuming Kelly could be the APOE for all outbound shipments (an optimistic assumption), the payback period for consolidation is 5.83 shipments.

**Two-Site Consolidation**

The cost for the two-site consolidation option was also calculated for assembling one standard deployment package at each of the two consolidation locations by shipping the necessary UTCs from the twelve AETC bases. Again, this cost was doubled to account for the initial deployment and return from the consolidation locations. As previously stated, two complete packages cannot be created due to a lack of equipment, so priority was given to the east coast and a partial package was assembled for the west coast.

	McChord	Travis
Charleston	\$ 198,600.00	\$ 179,400.00
Dover	\$ 222,800.00	\$ 206,800.00
McGuire	\$ 200,800.00	\$ 183,200.00

Table 6. Two-Site Package Shipping Cost

A modified version of the same linear programming model used for the single-site option was used to determine which UTCs to ship from which base in order to minimize the transportation cost while obtaining all necessary UTCs to create a standard package at each location (minus shortages). The minimum cost for assembling one standard package at each of the two consolidation points is shown in Table 6.

The cost for a one-time move of all UTCs to the pair of consolidation locations was also calculated. The same Excel linear programming model used for the two-site baseline was used for this, with the requirement that all UTCs be divided evenly between the two locations by distance and that every UTC be sent to one of the two consolidation locations. The minimum cost for these one-time moves is shown in Table 7.

	McChord	Travis
Charleston	\$ 229,500.00	\$ 215,100.00
Dover	\$ 259,200.00	\$ 246,900.00
McGuire	\$ 231,400.00	\$ 218,300.00

Table 7. Two-Site One-Time Move Cost

Similar to the analysis for the single-site model, a payback period for consolidation was calculated, as seen in Table 8.

	Two- Site Cost	Consolidation Cost	Payback Period (# of two-package taskings)
Charleston-McChord	\$ 198,600.00	\$ 229,500.00	1.16
Dover-McChord	\$ 222,800.00	\$ 259,200.00	1.16
McGuire-McChord	\$ 200,800.00	\$ 231,400.00	1.15
Charleston-Travis	\$ 179,400.00	\$ 215,100.00	1.20
Dover-Travis	\$ 206,800.00	\$ 246,900.00	1.19
McGuire-Travis	\$ 183,200.00	\$ 218,300.00	1.19

Table 8. Two-Site Payback Period

Table 8 shows that shipping two packages is almost the cost of consolidating the entire inventory at two consolidation sites. This payback period calculation is not equivalent to the single-site payback period calculation in that it compares the cost to ship two packages versus the cost to consolidate the inventory.

### Managerial Analysis and Implications

Along with cost savings, there are several additional benefits to consolidating equipment. The first benefit is the savings in manpower and hours required to inspect, maintain, and prepare equipment for deployment. The twelve bases involved in this study report a total of 1248 hours per month required to inspect, maintain, and prepare the UTCs. Based on the estimates provided by HQ AETC/A7S, at a consolidated location these same tasks could be accomplished in 402 hours, which translates to a savings of \$416,000 per year. The second benefit 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. In addition, reduction in lead time variation should also lead to reduced safety stock needed at the consolidation point [5]. The third benefit is standardization, both in inspection and storage of equipment. The twelve bases report a wide range of inconsistency in equipment inspection. The primary purpose of standard UTC packages is that each UTC will be the same regardless of origins. This is essential in the Air Force tasking process where equipment from one base may be matched with personnel from another. The same assumption must be made for the readiness of the equipment at its storage location. In this case, inspections were reported as ‘quarterly’, ‘monthly’, and ‘annual’, with bases reporting different standards for the same UTC. With consolidation, inspections, maintenance, and readiness of the UTCs could be standardized. Finally, the fourth benefit with consolidation is there would be a greater ability to manage the inventory for planning purposes.

## CONCLUSIONS

Based on the finding of this study, the Air Force will be able to implement the use of the Excel model created during this study to determine UTC equipment taskings for overseas deployments. This model will provide the minimum cost selection of UTCs to fulfill a particular tasking and can be adjusted if changes occur in shipping costs, number of UTCs available or required, or number of standard packages required. Further, it is recommended that the Air Force implement consolidation of security force UTCs. While there is an upfront cost associated with moving all the UTCs to a consolidation point(s), the payback period is less than three deployments in almost every case. Also, an issue that needs to be considered, but was beyond the scope of this study to quantify, is 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, significantly outweigh the potential risks. Acceptance of the results and conclusions of this study by officials at Randolph AFB have led to a second much larger study which includes the potential consolidation of all security forces equipment UTCs at over 60 installations across the Air Force. Such consolidation will offer the potential of post-implementation results. Another area for research is the effect of consolidation on training requirements. This would provide insight regarding the benefits and challenges associated with meeting training requirements at dispersed bases when necessary equipment may only be available at centralized locations.

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