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Pure pallets: effectiveness and efficiency impacts on the defense transportation system

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PURE PALLETS: EFFECTIVENESS AND EFFICIENCY IMPACTS ON THE DEFENSE TRANSPORTATION SYSTEM

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ABSTRACT

The military supply chain must explore initiatives to improve its ability to meet warfighter needs. One initiative, developed during operations in Afghanistan and Iraq is the *pure* pallet process—by consolidating material early in the supply chain into user-specific pallets, these pallets are able to transit the defense transportation system without being broken down en route, theoretically arriving to the warfighter in less time than prior break-bulk methods required. The pure pallet initiative's effectiveness and efficiency was assessed by measuring customer requisition wait time, cargo throughput, and revenue performance. It was found that effectiveness increased, without corresponding losses in efficiency.

BACKGROUND

Initial analyses show that the defense transportation system has not yet fully learned the logistics lessons of the 1991 Gulf War. A December 2003 Government Accountability Office (GAO) report investigating the preliminary effectiveness of Operation Enduring Freedom identified what it termed as "substantial logistics support problems" (Solis 2003). In particular, the GAO identified "[i]nsufficient and ineffective theater distribution capability" as a major problem. They state "[t]he distribution of supplies was also delayed because cargo arriving in shipping containers and pallets had to be separated and repackaged several times for delivery to multiple units in different locations" (Solis, 2003, p. 3).

In 1993, the defense transportation system stakeholders also recognized that improvements to the supply chain were critical to expedite the flow of material to the warfighter and to relieve congestion at the aerial ports of debarkation during Operation Iraqi Freedom (Kuntz, 2004). Prior to Operation Iraqi Freedom, improvements in the supply chain focused primarily on the link between the factory and the ports of debarkation. The rapid movements by combat forces during the Iraq war taught military logisticians the critical need to streamline the flow from the debarkation ports to the warfighter—"the last tactical mile" as well (Bivona et al., 2004, p. 76).

Establishing the Pure Pallet Process

In July 2003, a Defense Distribution Center representative visited Kuwait to review Central Command's distribution system and assist in identifying areas of improvement. It was discovered that the method employed to consolidate material and build pallets in the U.S.-based consolidation and containerization points was creating a substantial backlog of pallets upon arrival at the debarkation ports and theater distribution center due to the high volume of material and excessive handling requirements of pallets arriving into the theater. An important consequence of the saturation was the substantial increase in the warfighter's wait time for supplies at the "point of the spear" (Hornung, 2004). A more alarming concern was that soldiers were unnecessarily being placed in harm's way—the process of breaking down, sorting, and rebuilding pallets made soldiers vulnerable to attack (Diamond, 2004; Imberi, 2004; Merriweather, 2005).

In October 2003, Defense Distribution Center staff sponsored a meeting among the defense transportation system supply chain stakeholders. The team determined that requisitioned material should be held as far back in the supply chain as possible where the infrastructure was in place to efficiently hold and consolidate it. The ideal locations to position the cargo were determined to be the U.S.-based containerization points: the Defense Distribution Depot Susquehanna, the Defense Distribution Depot Red River, and the Defense Distribution Depot San Joaquin (Hornung, 2004).

The team also elected to build the consolidated material at the containerization points into end-user specific pallets called *pure* pallets. By consolidating material into pure pallets, the material would flow to the warfighter without being broken-down en route. This is unlike the historical process, which was based on break-bulk pallets that were broken down in-theater and the material sorted and re-palletized before being moved forward to the warfighter (Kuntz, 2004). This new approach seemed logical—the open desert environment and chronic lack of personnel certified to build air pallets made the theater distribution centers better suited for pallet cross-docking than for break-bulk activities and pallet construction.

Air Mobility Command's Air Transportation Division planners then defined a pure pallet as "...a pallet, which contains only shipments for the end-users at a single military destination. They also realized that certain low-volume destinations would be inefficient. Therefore they stipulated that in some instances the historical approach could be used, by combining specific users with a designated single or lead destination. Pallets constructed in this way are said to be *mixed* pallets. Pallets were to be capped when sufficient cargo was available to fill the pallet, or when the oldest piece of cargo reached a hold time of 48 hours.

In November 2003 the pure pallet process was placed into action at the Susquehanna depot. In support of Central Command's route plan, Susquehanna established 47 pure pallet build lanes to service 47 associated destinations. In addition, the Army's maximum allowable cargo hold time was increased from 48 hours to 120 hours and the Marine Corps' cargo hold time was increased from 48 hours to 72 hours (Hornung, 2004). It was assumed that the increased cargo collection time would allow a sufficient volume of cargo to flow into the consolidation points to enable the pure pallets to meet or exceed the ideal 1.5 ton pallet weight previously established by regulations (Air Mobility Command, 2001).

In February 2004, the pure pallet process was expanded to include pure pallet construction at Charleston and Dover Air Force bases (Hornung, 2004). These aerial ports were ideal due to their location in the defense transportation system supply chain, which allowed them to collect and consolidate Central Command-destined material that had bypassed the containerization points. This initiative is still new and is continuing to evolve rapidly. While the initial assessments were positive, they were largely based on opinion. The research goal was therefore to objectively study the process, using specific criteria for effectiveness (requisition wait time) and for efficiency (monthly tonnage and transportation revenue performance).

DEFENSE TRANSPORTATION VS. COMMERCIAL PRACTICE

When considering the challenges facing the defense transportation system, it is easy to assume that it should operate much like its commercial counterparts. Upon closer investigation, several key differences are readily identifiable. A paper by the University of Pennsylvania's Wharton School notes that the military supply chain can be categorized as three distinct chains, involving commodities, major components and people (Wharton, 2003). The Wharton paper also highlights the seriousness of military supply—a retail outlet may suffer lost sales if supply runs out but in the military, soldiers can be killed if their on-hand stocks of fuel or munitions are exhausted. Some principal differences between commercial transportation and its defense counterpart follow.

Scale and Size

In Fiscal Year 2004, Air Mobility Command moved approximately 1.15 billion pounds (Derick, 2005), while FedEx shipped 1.2 billion packages amounting to more than 3.9 billion pounds during the same timeframe (Federal Express, 2004). Where the average FedEx package weighs approximately 3 pounds, Air Mobility Command often moves much heavier items. Furthermore, commercial companies such as FedEx and UPS limit their maximum pallet weights to approximately 2,200 pounds (Federal Express, 2004), while the Air Mobility Command Weekly Summary Reports indicate that their average pallet weighs between 3,000 and 5,000 pounds. Finally, Air Mobility Command must be equally adept at moving non-palletized cargo such as rolling stock, where the commercial companies need not be.

Predictability and Volatility

The defense transportation system challenge is not one of volume as much as of being able to meet the unpredictability and volatility brought about by global events. Companies such as FedEx and UPS are concerned with steady growth and profitability as goals that are realized by increasing efficiency, productivity, and market share (Robbins et al., 2004, p. 11). While the defense transportation system is also concerned with efficiency, it is more important that the system be able to respond to a large uncertainty of demand and be able to meet the needs of the warfighters, regardless of profitability. Robbins and his colleagues note that "The defense distribution system must deliver to places that profit-maximizing commercial firms might never visit, and it must procure and hold low-demand items that would never be cost-justified in the commercial sector" (Robbins et al., 2004, p. 12).

Commercial "Rainbow" Pallets vs. the Military Pure Pallet

The commercial mixed pallet, also known as a *rainbow* pallet, provides multiple products to a single customer on a single pallet (Schultz, 2003, p. 2). Rainbow pallets were developed because merchandisers demanded more frequent deliveries and bought smaller quantities, delivered to their door on a just-in-time basis. This requirement has become more widespread to include most industries serving the retail trades, resulting in intense pressure to "do or die" (Hammond, 1999, p. 2).

By purchasing "the right amount of goods", which is usually less than a full pallet, the merchandiser customer is not required to maintain additional warehouse space to store excess product. Their challenge is to determine whether the increased transportation cost of more frequent deliveries outweighs the cost of excessive inventory and warehousing if rainbow pallets are not used. In contrast, the pure pallet process designers must consider more than just the velocity at which material reaches the warfighter. The pure pallet process must also accommodate the proper balance between process effectiveness (i.e., velocity), and process efficiency (i.e., acceptable use of scarce transportation assets). For example, standard commercial shipping pallets are typically low cost wooden items that can be easily obtained. Furthermore, the transportation assets themselves—typically trucks—are also widely available. Distributors can secure additional trucking if necessary, and the customer needs only to accept the additional cost as a tradeoff for velocity. In contrast, military airlift aircraft and pallets are scarce, and wartime pallet attrition is significant. Peterson notes that of the more than 180,000 standard "463-L" military airlift pallets available prior to September 2001, only about 85,000 were accounted for by December 2004. The pallets themselves are costly to buy and maintain: the Air Force spent almost $24 million for 463-L pallet repairs in 2004 (Peterson, 2005, p. 31).

The pure pallet concept is similar to the commercial industry's rainbow pallet, in that the defense transportation system must also balance tradeoffs of velocity versus transportation cost, warehousing space, and inventory. The key difference is that the pure pallet process is made considerably more complicated by the additional constraints of limited airlift assets.

Before explaining the research methodology, a brief discussion of effectiveness and efficiency metrics is necessary. To measure defense transportation system effectiveness, requisition wait time—the time that elapses from an item's order to the date it is received—was a clear choice (see e.g., Solis, 2005, p. 19). To assess efficiency, the measure used is cargo throughput, in terms of both pallet loading and aircraft usage. The hypothesis was that the time criterion for capping pure pallets would lead to lighter average pallet loads, which in turn would lead to lighter, less efficient aircraft loads. Pallet weight computations would be straightforward due to the standard 463-L pallet specification, but a corresponding aircraft usage metric was needed that could be readily applied across the multiple aircraft types used by Air Mobility Command. Fortunately, Air Mobility Command already uses precisely such an efficiency measure: the percent Transportation Working Capital Fund (% TWCF) goal.

The Transportation Working Capital Fund (TWCF)

Title IV, Section 405, of the National Security Act of 1947, *Working Capital Funds,* authorizes the use of revolving accounts to finance certain commercial-type activities in the Department of Defense. Airlift services reimbursement is received by the TWCF from authorized airlift customers by charging tariffs based on the type of airlift service provided. These tariffs are developed by U.S. Transportation Command planners and approved by the Undersecretary of Defense, Comptroller, through the President's Budget Cycle. Revenues earned by the TWCF recoup direct and indirect costs, general and administrative support provided by others, depreciation, and amortization costs incurred by Air Mobility Command in providing airlift services (Air Mobility Command, 2004, p. 7).

TWCF airlift tariffs for routine passengers and cargo are set annually based on commercial competition or a standard rate per mile. As a result, the TWCF doesn't recover full costs due to Air Mobility Command's requirement to maintain the wartime capacity of the airlift system. The difference between the revenue that the TWCF receives and the costs incurred for these airlift services is offset by an Air Force operations and maintenance-funded readiness account (Air Mobility Command, 2004, p. 8).

Air Mobility Command's Financial Management and Comptroller division determines the standard aircraft usage level for passengers and cargo to meet the Transportation Working Fund Goal. The goal is for the Air Force to provide a service to the customer cheaper than they can buy it commercially. In order to remain competitive the Air Force accepts some financial loss on each flight. The TWCF goal is set to defer most, but not all of the cost (Hobin, 2005). For example, in March 2005 the percent TWCF goal was 49.8% for passengers and 63.3% for cargo (Hobin, 2005). Therefore in March 2005, if an airlift aircraft was loaded to 63.3% of its cargo capacity, then it met its TWCF goal. When Air Mobility Command exceeds the TWCF goal, then they are operating cheaper than their commercial competition and they are operating efficiently by exceeding the expected TWCF input (Hobin, 2005).

METHODOLOGY AND ANALYSIS

To examine pure pallet impacts to defense transportation system efficiency and effectiveness, a case study of airlift-based material support to Central Command was conducted, comparing pre-pure pallet throughput (denoted as "historical" throughput) versus pure pallet throughput into the Central Command theater. Requisition wait time, average pallet weight and percent Transportation Capital Working Fund (%TWCF) goal-per-mission metrics were used to compare historical (March 2003–February 2004) pallet data to pure pallet (March 2004–January 2005) data.

Qualitative sources included published interviews and communications with military personnel involved in pure pallet implementation. Quantitative data sources included the RAND DOD-wide distribution database (for requisition wait time), Air Mobility Command's Weekly Summaries for the Charleston and Dover Air Force Base aerial ports (for pallet weights), and Air Mobility Command's Tanker Airlift Control Center end-of-month reports for Charleston and Dover Air Force Bases (for % TWCF goal). This article focused on the Dover and Charleston aerial ports because virtually all Central Command-designated pure pallets transit these two ports.

Requisition Wait Time

Figure 1 shows how the monthly pure pallet mean requisition wait times compare to the historical method, for cargo palletized at Dover or Charleston (denoted as "MILAIR" pallets). Figure 2 depicts the same information, for cargo palletized by the Defense Logistics Agency at the Susquehanna, Red River, or San Joaquin depots (denoted as "MILALOC" pallets). To ensure an accurate picture is presented, the tonnage of material transported into the Central Command theater is also shown in each figure, as is the Army's maximum 20-day requisition wait time goal. The associated data is shown in the Appendix. Note that for the Central Command MILAIR requisition wait times, the historical mean and median were 35.2 days and 30.1 days, respectively, while the pure pallet initiative mean and median values were 31.3 and 25.5 days, respectively. Using a two-sample t-test assuming unequal variance, it was found that the difference in mean requisition wait times is statistically significant ($p = 0.048$). Average monthly cargo throughput was about 10,500 tons across both timeframes.

Figure 2 shows that the historical mean and median Central Command MILALOC requisition wait times were 27.6 days and 23 days, respectively, while the corresponding pure pallet initiative mean and median values decreased to 23.5 and 19.8 days. The difference in mean requisition wait times is statistically significant ($p = 0.006$). Average monthly volume was again about 10,500 tons across the entire period. Similar findings were reported in a GAO report by Solis from data collected since February 2005 (Solis, 2005). These trends suggest that the pure pallet initiative is helping to reduce Central Command customer wait time.

FIGURE 1
REQUISITION WAIT TIME, PALLETS BUILT AT DOVER OR CHARLESTON

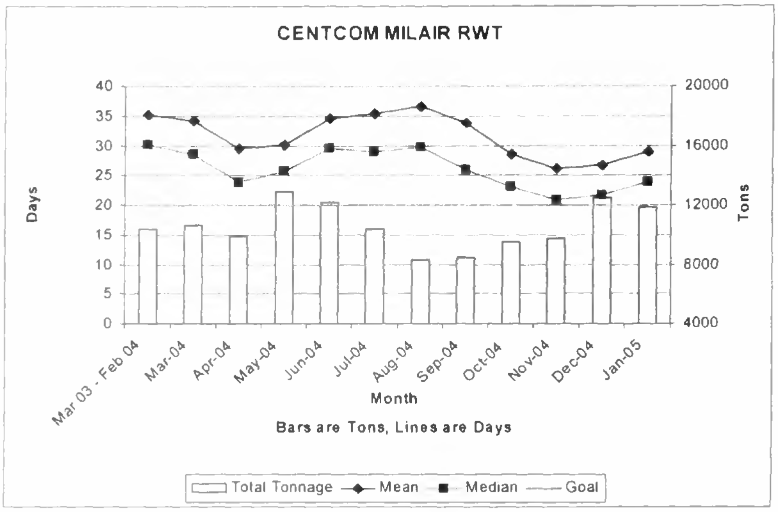
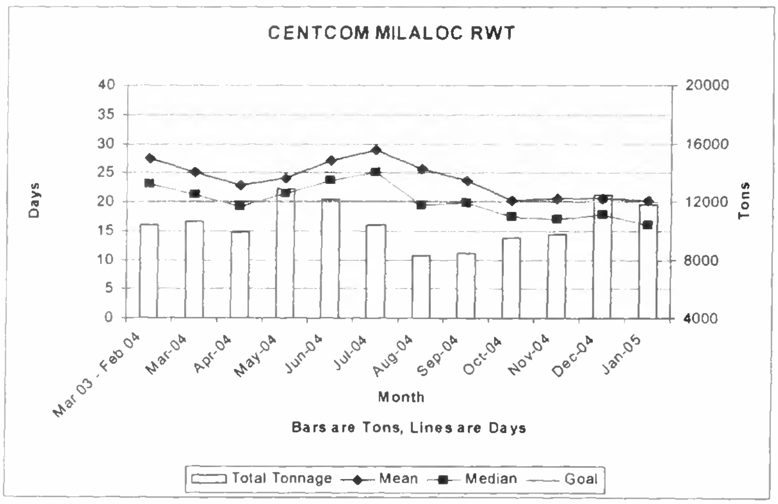


FIGURE 2
REQUISITION WAIT TIME,
PALLETS BUILT BY SUSQUEHANNA, RED RIVER, OR SAN JOAQUIN DEPOTS



Pure Pallet Weight

Figure 3 compares the average pallet tonnage for Dover AFB both before and after pure pallet implementation. The Missions numbers were generated from the reported data for the three primary airlift assets, the C-5, C-17, and the B747 as shown in the Appendix, records 1 through 4, 9 and 10. Figure 4 provides similar insights for Charleston AFB—the associated data is in the Appendix, records 5 through 8, 11 and 12.

Dover Throughput. The historical average Dover AFB pallet weighed 1.4 tons, but increased to an average of 1.76 tons for port-built (MILAIR) pure pallets. The MILALOC pure pallets transiting Dover averaged 1.6 tons. Taken together, Dover MILAIR and MILALOC pure pallets averaged 1.68 tons. The difference in mean tonnage, historical versus combined MILAIR and MILALOC pallets, is statistically significant ($p = 0.0004$). The average number of airlift missions through Dover AFB was 107 per month during the historical period, but decreased slightly to 102 per month during the pure pallet period.

Charleston Throughput. MILAIR pallets built at Charleston increased from 1.9 tons average weight to 2.13 tons after pure pallet implementation. The MILALOC pure pallet weight averaged 1.73 tons. Overall, MILAIR and MILALOC pure pallets together averaged 1.93 tons per pallet. Charleston averaged about 139 Central Command airlift missions per month during the historical period, but dropped to 105 per month during the pure pallet timeframe. Note that while the difference in mean tonnage, historical versus MILAIR pallets is statistically significant ($p = 0.017$), the difference in mean tonnage, historical versus combined MILAIR and MILALOC pallets is not ($p = 0.33$).

In summary, the pure pallet process appears to be helping increase average pallet weight—at the least, average pallet weight has not declined since the process was adopted. One might argue that the pure pallet initiative is affecting the number of monthly airlift missions, given their decrease during the study period, but this is unlikely. Too many other factors are also involved, such as competition for airlift aircraft for other missions, poor weather, and customer demand.

Percent TWCF Revenue Performance

Figures 5 and 6 compare the average %TWCF per month for Dover and Charleston Air Force Bases before and after pure pallet implementation. Both the missions and the %TWCF were generated from the reported data for the three primary airlift assets, the C-5, C-17, and the B747. The Appendix contains the applicable statistical measurements: refer to records 9, 10, 13, and 14 for Figure 5, and records 11, 12, 15, and 16 for Figure 6.

FIGURE 3
AVERAGE PALLET WEIGHT, DOVER AIR FORCE BASE

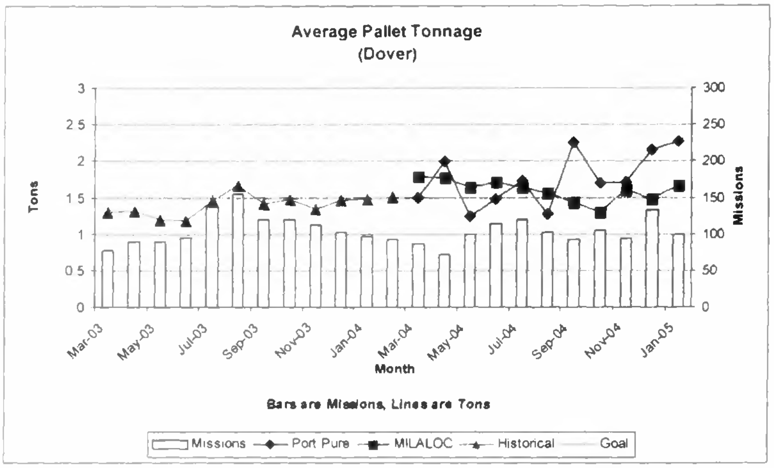


FIGURE 4
AVERAGE PALLET WEIGHT, CHARLESTON AIR FORCE BASE

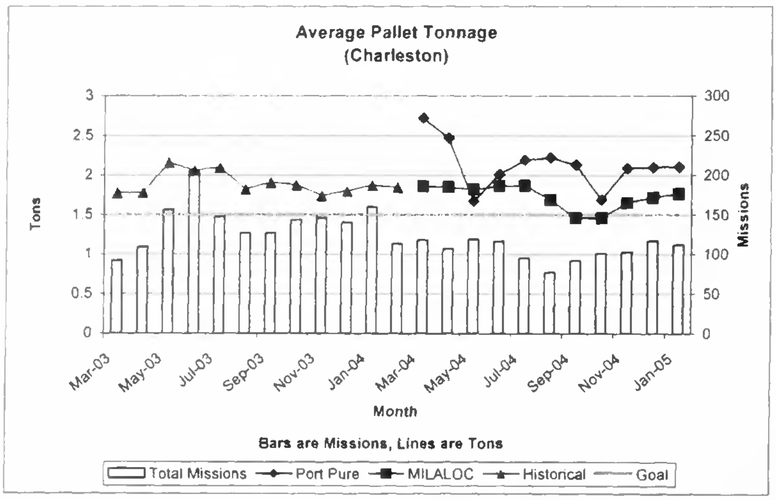


FIGURE 5
AVERAGE PERCENT TRANSPORTATION WORKING CAPITAL FUND REVENUES, DOVER AIR FORCE BASE

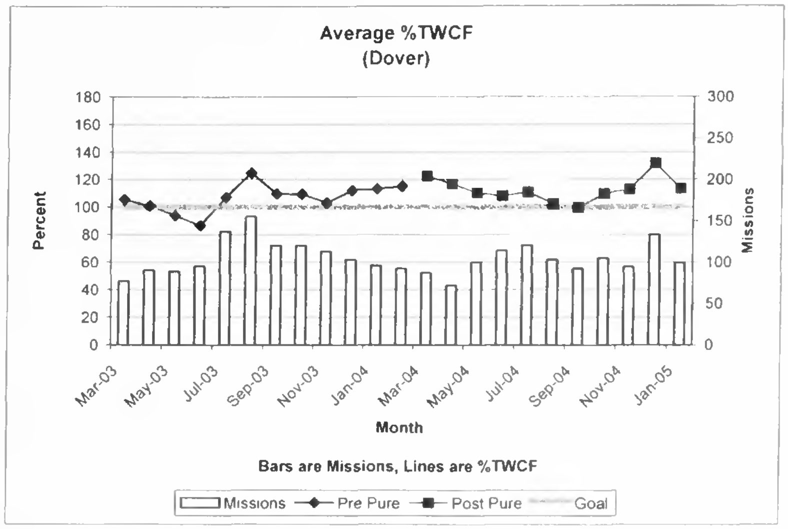
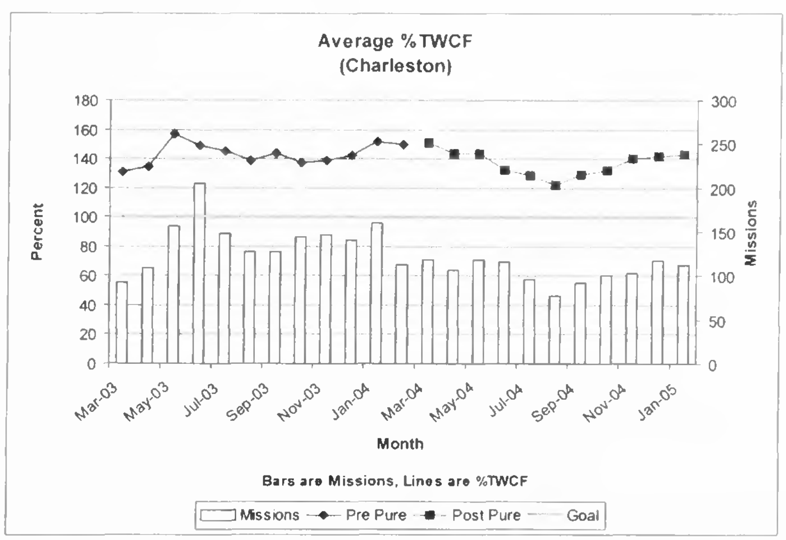


FIGURE 6
AVERAGE PERCENT TRANSPORTATION WORKING CAPITAL FUND REVENUES, CHARLESTON AIR FORCE BASE



During the March 2003–February 2004 historical period, Dover AFB averaged 106.7 percent TWCF revenues per month, but increased to an average 112.5 percent after pure pallet implementation. The statistical significance between the historical versus pure pallet %TWCF revenue performance is somewhat weak ($p = 0.076$). In contrast, Charleston AFB averaged 143.1% TWCF during the historical period, but declined slightly to 137% TWCF after the pure pallet process was initiated. This difference is statistically significant ($p = 0.045$). Overall, there appears to be a mild negative impact on the %TWCF revenue per mission. However, the %TWCF revenue continued to easily exceed the Air Mobility Command goal after the pure pallet process was implemented.

CONCLUSIONS

Pure pallet process implementation appears not to have reduced the defense transportation system's efficiency in the Central Command area of responsibility and in most circumstances is correlated with improved system effectiveness. The defense transportation system might never be fully optimized, but by continuing to implement ground-breaking initiatives along with lessons learned from commercial industry, the Department of Defense is making strides toward becoming a truly seamless end-to-end supply chain.

This research has shown that the pure pallet concept is correlated with increased velocity of material to Central Command warfighters, at minimal impact to transportation system efficiency. However, pure pallets are probably not a panacea for all military material distribution situations. For example, pure pallets increase the workload in the earlier stages of the supply chain (Robb, 2004, p. 22). Therefore, in situations such as a stable theater with a mature logistics system in a non-combat environment, the trade-off between velocity and increased workload may not be acceptable, such as in non-military sectors. It does, however, have potential application in disaster response situations.

Future research will investigate pallet attrition and retrograde issues, which was a significant challenge before the pure pallet concept was initiated. The pure pallet concept may be exacerbating the problem—during historical breakbulk pallet operations, the pallets would be broken down at the points of debarkation and the material loaded on trucks for delivery to the warfighters, leaving the 463-L airlift pallets and associated netting for return to the U.S. In contrast, the pure pallet concept pushes the airlift pallets much closer to the warfighter, rendering pallet retrograde more difficult.

Other research will address the 72 and 120-hour hold times that were established early in the pure pallet process formation, with little or no available data. Sufficient data now exists to determine optimal hold times. Hopefully, these hold times can be reduced without system efficiency impacts.

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APPENDIX
STATISTICAL SUMMARIES

#	1	5	9	13
	Pallet Tonnage Historical (DOV Mar 03 - Feb 04)	*Pallet Tonnage Historical (CHS Mar 03 - Feb 04)*	*Missions Pre-Pure Pallet (DOV Mar 03 - Feb 04)*	*% TWCF Pre-Pure Pallet (DOV Mar 03 - Feb 04)*
Mean	1.40	1.90	107	106.7
Standard Error	0.04	0.04	7	2.9
Median	1.44	1.86	100	108.1
Mode	#N/A	#N/A	120	#N/A
Standard Deviation	0.14	0.14	23	10.0
Sample Variance	0.02	0.02	509	99.9
Kurtosis	0.05	-0.36	0	0.8
Skewness	0.06	0.96	1	-0.4
Range	0.49	0.41	78	38.2
Minimum	1.19	1.74	77	86.6
Maximum	1.67	2.16	155	124.7
Sum	16.85	22.76	1287	1280.2
Count	12	12	12	12

#	2	6	10	14
	Pallet Tonnage Port Pure (DOV Mar 04 - Jan 05)	*Pallet Tonnage Port Built Pure (CHS Mar 04 - Jan 05)*	*Missions Post-Pure Pallet (DOV Mar 04 - Jan 05)*	*%TWCF Post-Pure Pallet (DOV Mar 04 - Jan 05)*
Mean	1.76	2.13	102	112.5
Standard Error	0.11	0.09	5	2.7
Median	1.71	2.11	100	110.9
Mode	#N/A	#N/A	#N/A	#N/A
Standard Deviation	0.37	0.30	17	8.9
Sample Variance	0.14	0.09	274	79.0
Kurtosis	-1.30	0.79	1	1.2
Skewness	0.14	0.31	0	0.8
Range	1.02	1.05	61	32.0
Minimum	1.25	1.67	72	99.6
Maximum	2.27	2.72	133	131.6
Sum	19.31	23.40	1119	1237.7
Count	11	11	11	11

#	3	7	11	15
	Pallet Tonnage MILALOC (DOV Mar 04 - Jan 05)	*Pallet Tonnage MILALOC (CHS Mar 04 - Jan 05)*	*Missions Pre-Pure Pallet (CHS Mar 03 - Feb 04)*	*% TWCF Pre-Pure Pallet (CHS Mar 03 - Feb 04)*
Mean	1.60	1.73	139	143.1
Standard Error	0.04	0.05	8	2.2
Median	1.64	1.77	142	142.8
Mode	1.64	1.86	127	#N/A
Standard Deviation	0.15	0.15	29	7.7
Sample Variance	0.02	0.02	847	58.7
Kurtosis	0.24	-0.16	2	-0.6
Skewness	-0.81	-1.01	1	0.2
Range	0.48	0.41	113	26.2
Minimum	1.30	1.46	92	130.8
Maximum	1.78	1.87	205	157.0
Sum	17.60	19.01	1667	1717.2
Count	11	11	12	12

#	4	8	12	16
	Average Pure Pallet Tonnage (DOV Mar 04 - Jan 05)	*Average Pure Pallet Tonange (CHS Mar 04 - Jan 05)*	*Missions Post-Pure Pallet (CHS Mar 04 - Jan 05)*	*%TWCF Post-Pure Pallet (CHS Mar 04 - Jan 05)*
Mean	1.68	1.93	105	137.0
Standard Error	0.06	0.07	4	2.6
Median	1.66	1.86	107	139.8
Mode	1.48	1.69	#N/A	#N/A
Standard Deviation	0.29	0.31	13	8.7
Sample Variance	0.08	0.10	176	75.6
Kurtosis	0.19	0.78	0	-0.7
Skewness	0.68	0.78	-1	-0.2
Range	1.02	1.26	42	29.2
Minimum	1.25	1.46	77	121.7
Maximum	2.27	2.72	119	150.9
Sum	36.91	42.41	1157	1507.0

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