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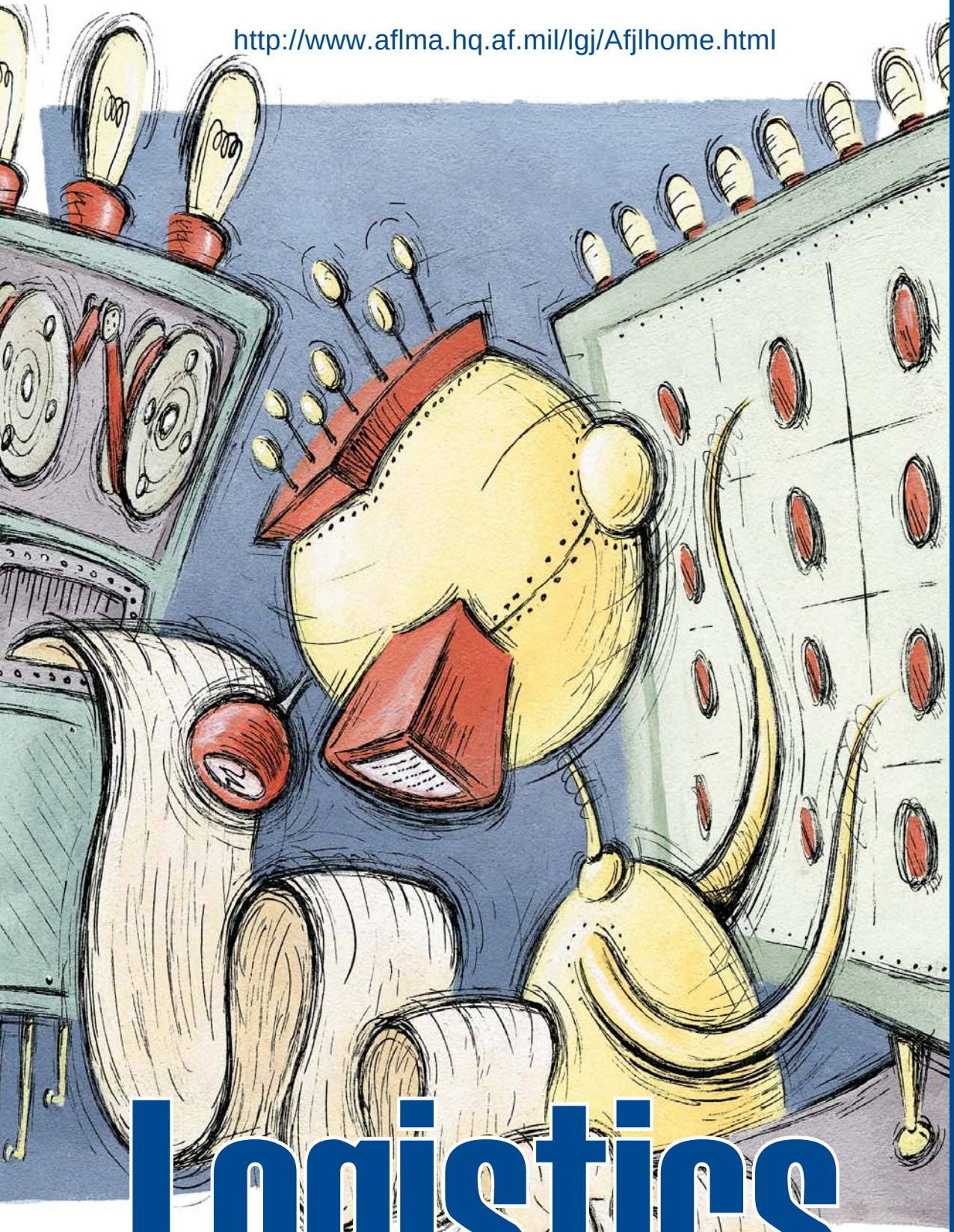

Logistics

Dimensions 2006

Air Force Deployments: Estimating the Requirement

Mending a Seam: Joint Theater Logistics

Analyzing Air Force Flying-Hour Costs

Improving Base Demand Levels Using COLT

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Special Feature

A historical review of US wars is replete with examples of a logistics system very capable of delivering strategic resources, but often failing in getting those resources from the port of debarkation to the actual point of consumption in a timely manner.

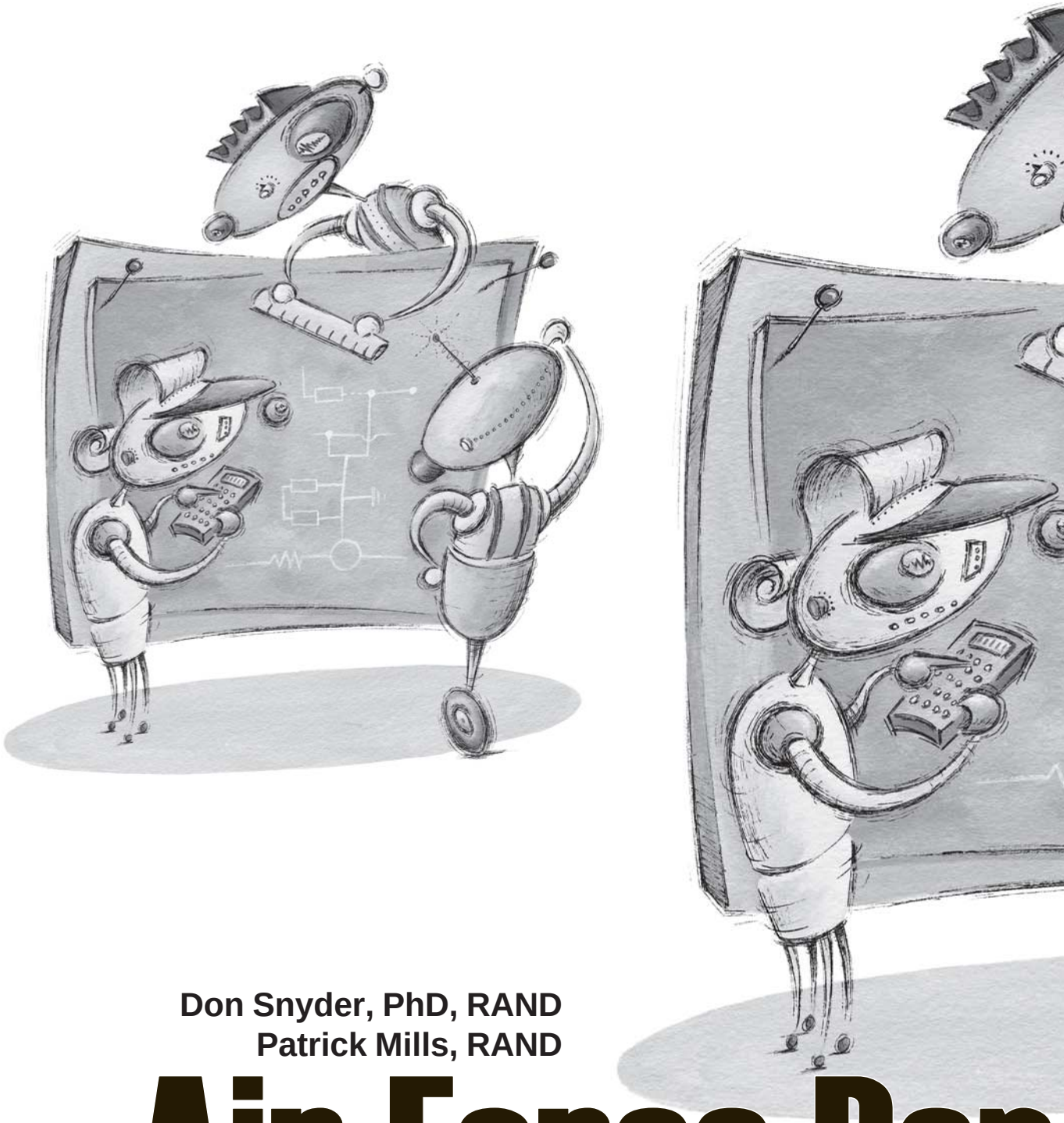
logistics Dimensions 2006

Air Force Deployments: Estimating the Requirement
Mending a Seam: Joint Theater Logistics

Structuring logistics to meet deployment and expeditionary requirements is one of the major dimensions of logistics today. Both of the featured articles examine ways to respond to the challenges associated with this dimension. The first article looks at what may be a better way to estimate Air Force deployment requirements. In this article, RAND proposes a parameterized rules-based approach for estimating deployment requirements. This method combines the speed at which planning can be done using force modules with the accuracy of the ad hoc approach.

There are many logistics seams between the *point of origin and the point of consumption*, but the largest seam is where strategic logistics meets theater logistics. The US military has done well at placing emphasis on strategic logistics. What it has not done is place that same emphasis and importance on theater logistics. Historically, the US military has a record of waiting until a contingency erupts to produce a theater logistics operation that gets the job done.

The second article examines a way to *mend this seam.* In it the article posits that by creating a Joint weapon system out of the Deployment and Distribution Operations Center (XDDOC) concept, the Department of Defense can mend the strategic-to-theater logistics seam and provide true Joint theater logistics. The XDDOC concept is not a panacea, but it appears to provide great promise towards improving theater logistics.



Don Snyder, PhD, RAND
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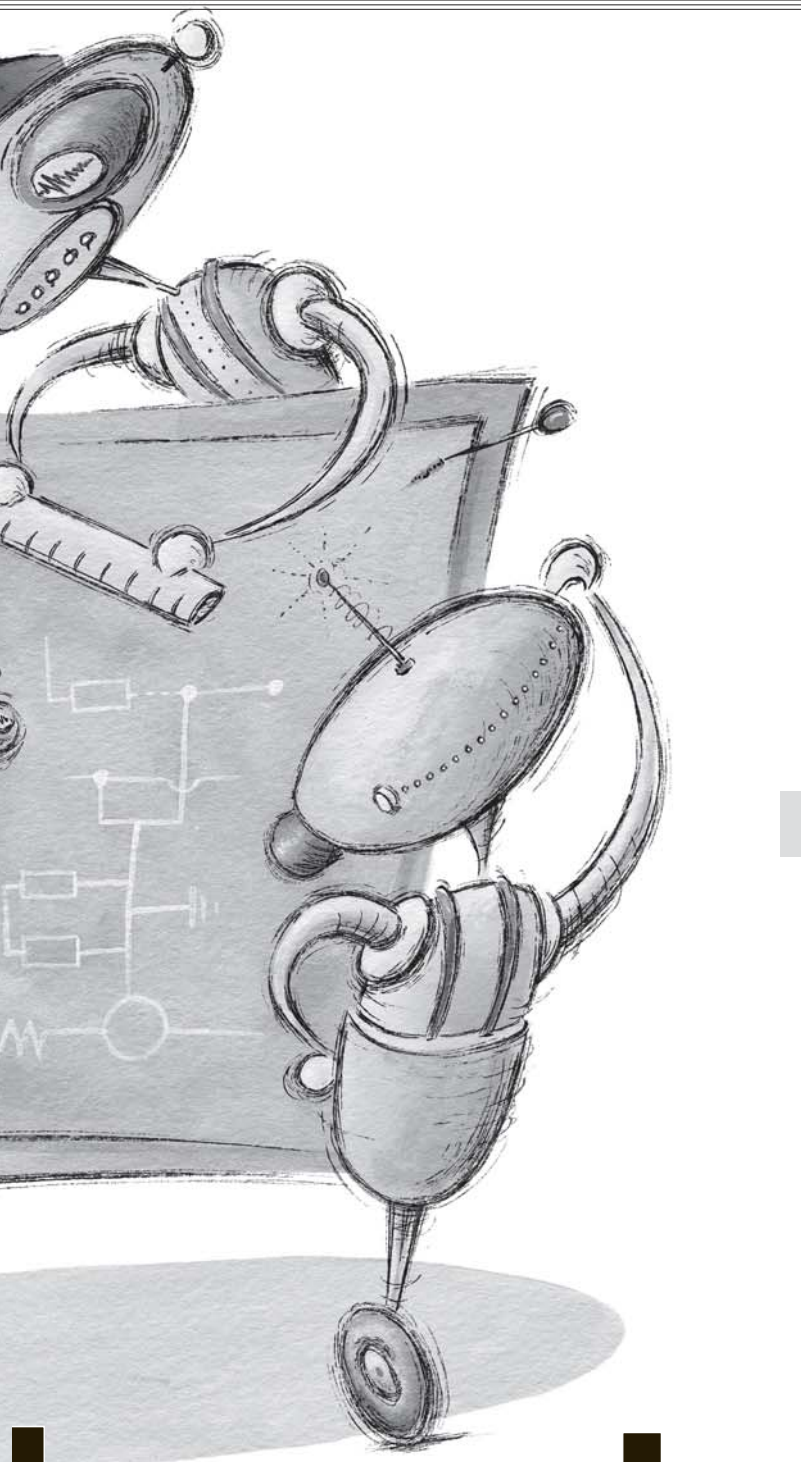

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Introduction

Flying combat aircraft out of deployed locations frequently requires deploying thousands of people and thousands of tons of equipment. Determining how much and what kind of each is not easy. Nevertheless, deploying the right amount and types of equipment and people is very important, both during the execution of contingency operations and for planning purposes. During operations, not having enough resources causes risk of not being able to perform the mission. Taking too much risk delays operations, because of unnecessarily tying up lift, or impairs operations elsewhere by unnecessarily tying up resources. During planning, misestimating the resources needed for deployments may lead to a force structure of the wrong size or balance to meet future national security needs.

Special Feature

Whether done for executing a contingency operation or for planning purposes, deployment resource requirements are principally expressed in the form of unit type codes (UTCs). UTCs are sets of equipment and manpower resources needed to perform a specified capability. They vary considerably in size, and the requirements for a deployment to a single base can involve over a hundred UTCs. Various approaches have been used to estimate which UTCs are needed for deployments.

Force Deployment Requirements

The direct way is to assemble an ad hoc group of subject matter experts for all relevant functional areas and have them assess their resource needs given relevant operational details of the contingency. We call this the ad hoc approach to deployment planning. This approach generally begins with a site survey and input information from operational planners giving details of aircraft to be bedded down, sortie rates, and other relevant factors. Requirements for each functional area are estimated by experts in that area. For example, given the size and numbers of aircraft expected at a base, civil engineers can estimate the water flow needed to meet fire-fighting needs. From this estimate, they determine how many and what types of trucks to deploy. Given the trucks, they in turn estimate the manning and managerial staffing. Other functional areas go through similar, often more complicated, procedures to estimate their resources. For many functional areas, however, the work does not stop at this point because the resource requirements in one area may impact another. For example, civil engineers planning for base support needs—such as number of billets and water and power requirements—need to know how many personnel are expected

Article Highlights

During planning, misestimating the resources needed for deployments may lead to a force structure of the wrong size or balance to meet future national security needs.

In "Air Force Deployments: Estimating the Requirement," the authors propose a parameterized rules-based approach for estimating deployment requirements. This method combines the speed at which planning can be done using force modules, with the accuracy of the ad hoc approach. It extends the concept of force modules from a list of unit type codes (UTC) that support nominal operations out of a generic base to an algorithm that generates a list of UTCs needed at a base that has specified infrastructure and supports specified aircraft and mission. The emphasis is on assembling the *rules* for selecting UTCs rather than assembling *lists* of UTCs. This methodology is called a *parameterized rules-based* approach to calculating deployment requirements. A prototype algorithm using a parameterized rules-based approach for estimating deployment requirements was recently developed by RAND, and is called the Strategic Tool for the Analysis of Required Transportation (START).

Such an approach is based on the principle that needs can be calculated accurately enough for planning purposes given a small set of driving factors. Many functional areas exercise such rules implicitly during planning. Most support needs can be estimated from the following: the number, type, and sortie rates of the aircraft at the location, and whether they are bedded down at the site, or use it as an enroute base; the level of risk that the site has from conventional and nonconventional attack; and a limited number of attributes of the existing infrastructure at the base, such as whether the base has a hydrant fueling system available to the deploying forces, if any billeting is available, and so forth. With these few driving factors and a set of rules, UTC lists can be estimated for most functional areas.

Rules for UTC deployment were developed by consulting a number of senior noncommissioned officers and logistics readiness officers. For purposes of demonstrating the concept, the following functional areas were covered: deployed communications, bare-base support, civil engineering (engineering craftsmen, fire protection, explosive ordnance disposal, and at the site. This number is determined by the sum of all the other functional areas' requirements. This interdependency forces some communication among the functional area experts, or iteration of estimates, or both. The process necessarily engages numerous personnel and consumes considerable time.

A second way is to determine, in advance of deployments, what is expected to be needed for a nominal deployment location. Such an effort has been recently pursued in the form of force modules. Force modules are sets of UTCs for supporting operations at a nominal location. Within the Air Force, the current implementation of force modules has been developed to estimate the resources needed to operate out of an austere deployed location. Five force modules have been developed.

- Open the base
- Establish the base
- Operate the base
- Provide command and control
- Generate the mission.

These modules represent an integrated capability that crosses many functional areas. The modules not only list UTCs, but also specify the order in which they need to arrive. The task of creating these force modules and testing their deployment at the Eagle Flag exercise has caused UTC contents and sizes to be adjusted for modularity.

Force modules can be viewed as a special case of the ad hoc approach to planning. Groups of subject matter experts have gone through the same process of building a UTC list as in the case for real deployments, except in the case of force modules, the target location is a generic, nominal bare base. Some of the assumptions made in the development of force modules are as follows.

- The base has a water source that can be made potable within 10 days.
- The base has limited fuel storage capability, but fuel is available from the host nation.
- General purpose vehicles can be obtained from the host nation.
- The base has a low to medium threat exposure.[1]

Having studied in advance the needs of a nominal deployed location and made a list of the required UTCs clearly saves time and effort when executing contingencies.

Both of these approaches to estimating deployment requirements have benefits and shortcomings. To see these more clearly, consider the Air Force expeditionary activities of the past few years. To support these contingencies, the Air Force has deployed to dozens of locations, nearly all of them unique in their support requirements. Total numbers of Air Force aircraft at these sites ranged from fewer than ten to more than a hundred. Different airframes have been collocated more often than not. In over half of the locations, aircraft from other services or coalition partners have shared the base with the Air Force. Additionally, the existing infrastructure at these locations varied widely. A few are truly bare bases, whereas more commonly, the airfield has some kind of usable infrastructure that reduces the resources the Air Force needs to deploy, such as an international airport or

coalition partner military airbase. Locations with usable infrastructure also vary considerably, both in the nature of the infrastructure and in how much is made available to deploying forces. Locations of recent deployments indicate that not only is there no typical base in the sense of infrastructure and numbers and types of aircraft, there are scarcely two that are alike.

How well do the ad hoc and force-module approaches handle the vicissitudes of these demands on expeditionary planning? Suppose, for the purpose of sizing the future force, the Air Force needed to estimate the deployment requirements for activities resembling recent contingencies. The ad hoc approach is capable of making good estimates of the UTCs needed to support operations at each of the locations. This accuracy, however, comes at a high cost in time, money, and manpower. Assembling these UTC lists can take teams of experts weeks or months. The costs can be prohibitive, especially if the number of sites to be investigated is numerous, or the number of scenarios to be examined are many.

Force modules economize on the time, money, and manpower of assessing requirements by having standardized these in advance. This economy was indeed one of the main motivations for their creation. Their weakness is that they do so for a generic base, yet no characteristic generic deployed location has emerged from recent deployments. The bases of interest in planning may depart significantly from the one envisioned in the development of the force modules, including such sites as international airports. Without tailoring, force modules fail to accurately capture the nuances of deployment requirements involving a range of base types and mixes of aircraft. These differences will reduce the economies of effort that the force modules would provide had they been able to account for the enormous range in types of Air Force deployed operations. Further, when used to size and shape the future force, they may not generate the best mix of capabilities to meet national security objectives given a constrained budget.

Here, we introduce a third way to estimate deployment requirements. The proposed method combines the speed at which planning can be done using force modules, with the accuracy of the ad hoc approach. This method extends the concept of force modules from a list of UTCs that support nominal operations out of a generic base to an algorithm that generates a list of UTCs needed at a base that has specified infrastructure and supports specified aircraft and mission. The emphasis is on assembling the *rules* for selecting UTCs rather than assembling *lists* of UTCs. We call this methodology a *parameterized rules-based* approach to calculating deployment requirements. A prototype algorithm using a parameterized rules-based approach for estimating deployment requirements was recently developed by RAND, and is called the Strategic Tool for the Analysis of Required Transportation (START)[2].

A Prototype: The RAND START Algorithm

A parameterized rules-based approach for estimating deployment requirements rests on the principle that expeditionary needs can be calculated accurately enough for planning purposes given a small set of driving factors. Consultations with subject matter experts in a range of support areas confirm this supposition[3]. Many functional areas exercise such rules implicitly during planning, such as the fire-fighting example given above. Most support needs can be estimated from the following.

Article Highlights

readiness), medical, force protection, fuels support, aviation and maintenance, and aerial port operations. The rules were vetted by calculating the needs for a variety of deployments and having these examined by subject matter experts not involved in the consultations used to establish the rules. Generally this meant conferring with experts from one major command to derive the rules, and consulting experts from another major command to vet the results. The method is similar to what is done in assembling UTC lists by the ad hoc method, or making the UTC lists that constitute force modules, except that what is being assembled is rules rather than UTCs.

The resulting rules were incorporated into Visual BASIC for Applications code hosted in an Excel spreadsheet. The Excel spreadsheet contains a list of available UTCs directly imported from the manpower and force packaging database. The user specifies operational details at approximately the level of an air order of battle. Inputs are in the form of checklists that specify the following parameters: which aircraft are bedded down at the location (or use it as an enroute location), how many of each type, their sortie rate, and mission. Some high-level aspects of the available base infrastructure can be selected, such as whether a fuels hydrant system is available, or how much billeting may be available. The user also indicates whether the threat to the base is high, medium, or low for both conventional and nonconventional attack. Finally, a working maximum on ground can be specified in order to estimate aerial port equipment and manpower. From these inputs, planning factors are used to calculate base population. The algorithm then takes these parameterized inputs and uses the rules to determine which UTCs are needed and how many. The algorithm searches the MEFPAK for these UTCs and collects the movement data that is compiled in the MEFPAK. The final output is a list of UTCs and their associated movement characteristics.

Article Acronyms

AEF - Aerospace Expeditionary Force
MEFPAK - Manpower and Force Package
MOG - Maximum on Ground
START - Strategic Tool for the Analysis of Required Transportation
UTC - Unit Type Code

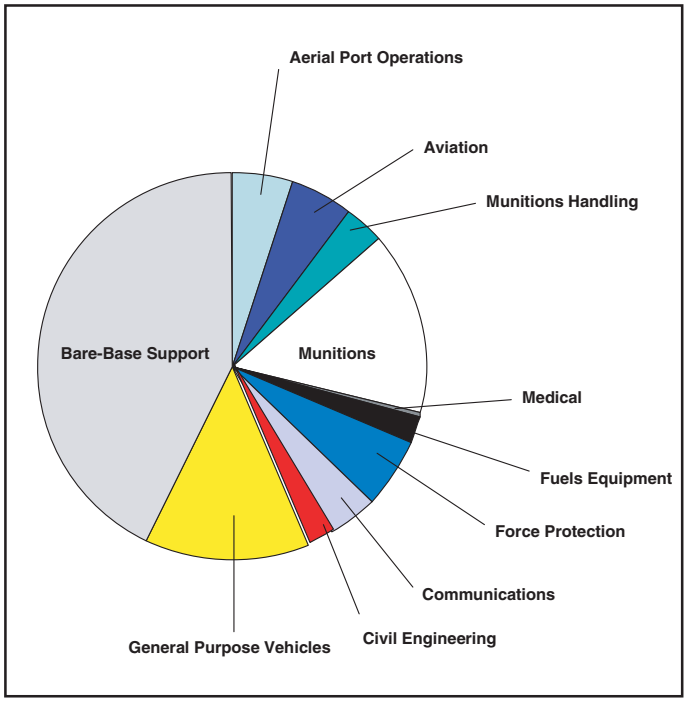

Figure 1. Summary of Support Requirements for a Deployment of a Squadron of F-16CJs and a Squadron of C-130s at One Location

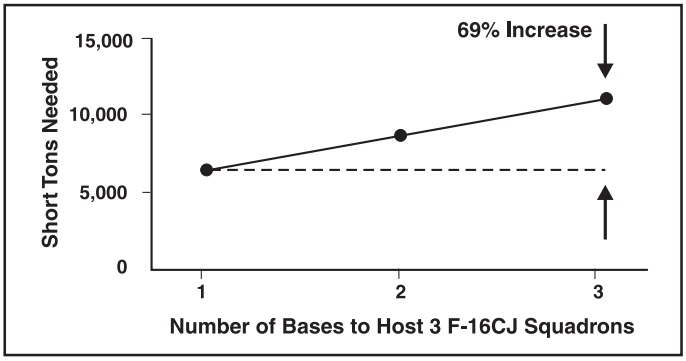

Figure 2. Plot Showing the Increase in Support Needs if 54 F-16CJs are Based at One, Two, or Three Bare Bases

- The number, type, and sortie rates of the aircraft at the location, and whether they are bedded down at the site, or use it as an enroute base
- The level of risk that the site has from both conventional and nonconventional attack
- A limited number of attributes of the existing infrastructure at the base, such as whether the base has a hydrant fueling system available to the deploying forces, if any billeting is available, and so forth

With these few driving factors and a set of rules, UTC lists can be estimated for most functional areas[4].

We assembled rules for UTC deployment by consulting a number of senior noncommissioned officers and logistics readiness officers. For purposes of demonstrating the concept, the following functional areas were covered: deployed communications, bare-base support, civil engineering (engineering craftsmen, fire protection, explosive ordnance disposal, and readiness), medical, force protection, fuels support, aviation and maintenance, and aerial port operations. The rules were vetted by calculating the needs for a variety of deployments and having these examined by subject matter experts not involved in the consultations used to establish the rules. Generally this meant conferring with experts from one major command to derive the rules, and consulting experts from another major command to vet the results. The method is similar to what is done in assembling UTC lists by the ad hoc method, or making the UTC lists that constitute force modules, except that what is being assembled is rules rather than UTCs.

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Illustrative Applications

The most straightforward illustration is calculating the requirements for a single base hosting a mix of aircraft. Figure 1 shows the requirements for a deployed location with 18 F-16CGs flying 1.5 sorties per day, and 8 C-130s, each flying one sortie per day out of a bare base with a MOG of 2. The threat levels for both conventional and nonconventional attack are taken to be low. This calculation takes a few seconds using the START program. The figure summarizes the requirement in terms of weight; for all functional areas calculated, the sum is 4,775 short tons. These results not only give a planner an excellent starting point for assembling an executable UTC list, but also provide a first-order estimate of the movement requirements. A user can adjust parameters such as the numbers of aircraft, their sortie rates, and so forth in order to examine the impact on the required UTC list. The power of the method is that the UTC list is not static, but can be derived from variations in these input parameters.

Now consider the issue of force lay down as an implicit parameter. For example, what is the difference in the support requirements of the following alternative for the lay down of 3 squadrons of F-16CJs flying 1.5 sorties per day: (1) all three collocated at one bare base; (2) two placed in one bare base and one in a second bare base; or (3) each squadron deployed to its

own bare base. Figure 2 shows the results, aggregating all equipment resources in terms of weight. To emphasize the resources that are likely to be deployed, the figure excludes general purpose vehicles. Placing the same numbers of aircraft flying the same mission at three bases rather than one increases the total support materiel by nearly 70 percent. This figure may be an underestimate of the increase, as it does not take into account the likely reduction in personnel needs that the economies of scale of a single base provides. The ability to perform tailored calculations like these can be a useful guide during both deliberate and crisis-action planning.

Finally, note that the algorithm can be used in two directions. A scenario can be created, and the deployment requirements calculated to meet those operational needs. The above calculations are examples of this direction, and this is useful in obvious ways for crisis-action planning, and planning for force sizing. Alternatively, a capability could be specified, such as the ability to deploy a set of aircraft to a number of sites of certain types. The required resources could then be compared with those currently authorized or available. This direction provides a nuanced way to express Air Force expeditionary capabilities, such as how many bases of a certain type can be supplied by an aerospace expeditionary force (AEF).

Implementing a Parameterized Rules-Based Approach to Deployment Planning

The program we have described is a prototype, concept demonstrator. Additional work will need to be done to make this approach operational. Much of the knowledge needed to implement a parameterized rules-based approach to estimating deployment requirements already exists. A knowledge base of rules for deployments has been developed by most functional areas, and if not yet formalized, exists *virtually* in the subject matter experts.[7]

Areas that have already developed algorithms to assist in estimating deployment, such as fuels support, can furnish such rules without further effort. For most areas, the rules need to be assembled. These could be assembled by a similar effort as was made in creating the force modules.

Caution should be exercised in extracting rules from historical deployments. We did not use historical data in assembling the rules in the prototype START program. Aside from the limitations of knowing what was not requested during a contingency (because it was already available), and the general reality that operational needs change nearly continuously with time, it is difficult to separate needs from wants. Materiel and manpower may be requested during an operation not just to cover the operational needs of the time, but also to mitigate risk in case of an unplanned surge in operations. These needs can be difficult to separate.

Once compiled, rules need only be maintained during the routine management of UTCs. As part of the introduction of new UTCs, the pilot unit could be responsible for developing rules for their deployment, just as they now are responsible for estimating movement characteristics. A secondary benefit of this process may be that it impacts the development of UTCs in the same constructive way that force modules have. A parameterized rules-based approach may reveal aspects in which the sizing and constitution of UTCs might be improved to meet expeditionary needs. For example, in some areas, parameterization and rules collection might reveal value in establishing separate UTCs to supply a given capability to a bare base versus an international airport.

We hope this prototype effort will lead to the next step in the evolution of the force module concept, one that moves from UTC lists to sets of rules for deployment. Doing so should further advance the expeditionary mission of the Air Force.

Once compiled, rules need only be maintained during the routine management of UTCs.

Notes

1. Lt Col Raymone Mijares, Presenting the AEF-AETF Force Modules, 2005.
2. Don Snyder and Patrick Mills, *A Methodology for Determining Air Force Deployment Requirements*, RAND MG-176-AF, 2004. The emphasis on transportation in the name START is because the algorithm was initially written as a component in an analysis of minimizing lift costs for deployments.
3. Don Snyder and Patrick Mills.
4. Other factors can play a role. For example, base layout and topography may influence the needs for vehicles and place greater demands on security forces. If topography impedes line-of-sight communications at the base, additional communications equipment may also be needed. These are secondary factors, and results can be tailored to accommodate these factors when they play a significant role.
5. In the START program, these planning factors for base population are used directly. Further refinement would use these estimates as *seeds* to calculate all manpower needs, then use the sum of the manpower needs as a second estimate of base population. The calculation would then be iterated until convergence.
6. No time-phasing or sourcing of the UTCs is currently done. Time-phasing could be introduced as a further refinement, and the outputs could easily be used as the inputs to an algorithm that does sourcing.
7. Lionel A. Galway, Mahyar A. Amouzegar, Richard J. Hillestad, and Don Snyder, *Reconfiguring Footprint to Speed Expeditionary Aerospace Forces Deployment*, RAND MR-1625-AF, 2002; Lionel A. Galway, Mahyar A. Amouzegar, Don Snyder, Richard J. Hillestad (2002) "Footprint Configuration: An Essential Element for Agile Combat Support in the EAF," *Air Force Journal of Logistics*, Vol XXVI, No 4, 20-26, 43; Don Snyder and Patrick Mills, *A Methodology for Determining Air Force Deployment Requirements*, RAND MG-176-AF, 2004.

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Introduction

Aptitude for war is aptitude for movement.

—Napoleon I

Special Feature

The United States is extremely capable of waging war, but its capability for moving, tracking, and controlling resources could be an Achilles heel during future conflicts if, as the military is transformed, the logistics system to create a seamless logistics capability that fully supports the warfighter is not also transformed.

In an effort to begin logistics transformation, the Secretary of Defense designated United States Transportation Command (USTRANSCOM) as the single distribution process owner for the Department of Defense (DoD), and charged USTRANSCOM with the overarching responsibility of ensuring the delivery of resources from point of origin to point of consumption with total-asset visibility (TAV). There are many logistics seams between the *factory and the foxhole*, but the largest seam is where strategic logistics meets theater (operational) logistics. This article posits that by creating a Joint weapon system out of the Deployment and Distribution Operations Center (XDDOC) concept, the DoD can mend the strategic-to-operational logistics seam and provide true Joint theater logistics.

Joint theater logistics is a complicated issue and involves many players, technology issues, and command relationships. This article will not address all the issues involved in mending the seam between strategic and theater logistics, but will concentrate on the United States Central Command (USCENTCOM) Deployment and Distribution Operations Center (CDDOC) Spiral 1 and what the report concerning the CDDOC describes as a way ahead.

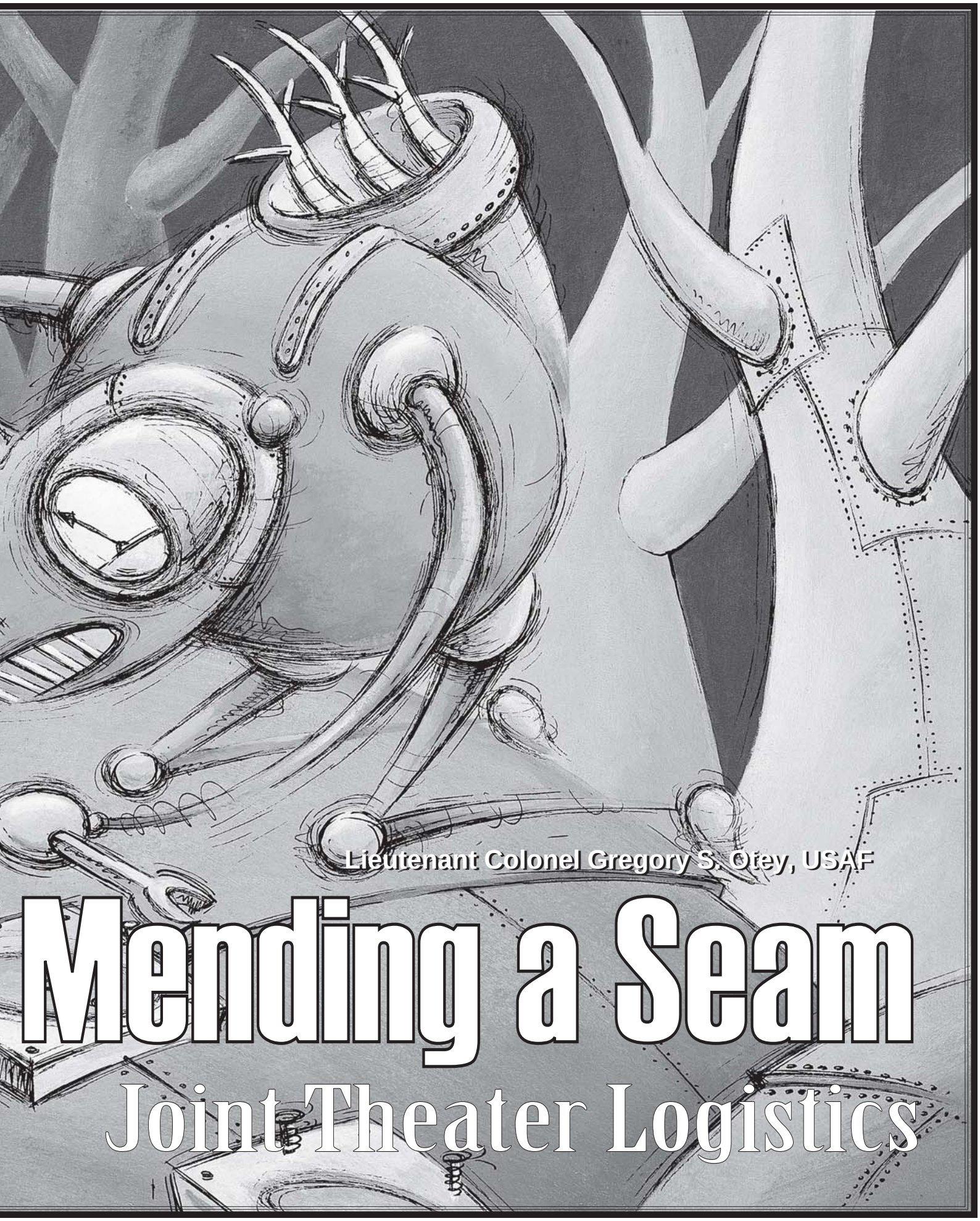
Historical Perspective Leading to the CDDOC

The current logistics apparatus was suited ideally to the battlefields of the Cold War, with more clearly defined front lines. It is not enough to ship supplies just to the nearest seaport or airfield. Nor can we solely depend on just-in-time concepts for fast-moving tactical forces. The current scenarios require a logistics infrastructure that can deliver supplies to the "last tactical mile…"

—Lt Gen Lawrence P. Farrell, Jr, USAF (Ret), President, National Defense Industrial Association

Logistics During World War II, Korea, Vietnam, and Desert Storm

A historical review of US wars is replete with examples of a logistics system very capable of delivering strategic resources,



Lieutenant Colonel Gregory S. Otey, USAF

Mending a Seam

Joint Theater Logistics

Article Highlights

There are many logistics seams between the *factory and the foxhole*, but the largest seam is where strategic logistics meets theater logistics.

This article provides a historical perspective of logistics during World War II, Korea, Vietnam, Desert Storm, and Operation Iraqi Freedom, including present day logistics and the creation of the CENTCOM Deployment and Distribution Operations Center (CDDOC). It examines the CDDOC by looking at what worked during Spiral 1, as well as problems which still persist and need attention. It also examines the Deployment and Distribution Operations Center (XDDOC) concept through the lenses of doctrine, organization, training, material, leadership, education, personnel, and facilities. The article posits that by creating a Joint weapon system out of the XDDOC concept, the DoD can mend the strategic-to-operational logistics seam and provide true Joint theater logistics. In the final section the author provides recommendations concerning how the XDDOC concept can be upgraded.

The XDDOC concept is not a panacea, but does provide great promise toward improving theater logistics. Although the CDDOC Spiral 1 was very successful, problems still persist due to the lack of total intransit visibility and a command and control structure that worked logistics hand-in-hand with the warfighter. Creating a Joint weapon system out of the XDDOC

but often failing in getting those resources from the port of debarkation (POD) to the actual point of consumption in a timely manner. During World War II, Operation Overlord was ultimately a success, but the all important Normandy breakout came to a grinding halt because critically needed supplies could not reach lead echelons.

> …when the breakout from Normandy came and a tactical success was scored, full exploitation could not be achieved for lack of sufficient transportation…. In September, 1944 the allied armies halted their advance toward Germany because of lack of logistical support to the front, although there were ample supplies ashore in Normandy Base area, 300 miles away.[1]

Additionally, one can look at the Korean War for evidence of logistics struggles to get supplies to the *foxhole*. Joint Publication (JP) 4-01.3, *Joint Tactics, Techniques, and Procedures for Movement Control* cites the following example from the Korean War.

> Repeatedly [recalling the experiences of World War II], supplies were landed in such an excess of tonnage over the capabilities of the local logistic organization to cope with it, that pretty soon many things could not be found at all. The next thing, the Zone of the Interior had to rush out a special shipload of something which was right there in the theater—and always at a time when ships were worth their weight in gold. Soon the war moved on and supplies were left behind, which are still being gathered up and sorted out to this day [1953]. Two years after the Korean War started, I visited Pusan. They had been working hard, and by that time they had sorted out probably 75 percent of the supply tonnage there. Twenty-five percent of the tonnage on hand was not yet on stock record and locator cards; they did not know what it was or where it was.[2]

World War II and Korea provided numerous lessons observed but not learned as many of the same mistakes were made during the Vietnam War. Once again the logistics system did a good job of creating *iron mountains* of supplies. However, it eventually choked the PODs and was unable to get resources to the end user in a timely manner. The logistics system used in Vietnam was very stovepiped as "each Service requested and shipped its own equipment and supplies…" with no Joint oversight until the establishment of the Traffic Management Agency (TMA) in 1967.[3] General Heiser writes,

> …the zeal and energy and money that went into the effort to equip and supply US forces in Vietnam generated mountainous new procurements, choked supply lines, overburdened transportation systems, and for a time, caused complete loss of control at depots in Vietnam.[4]

Similarly, Desert Storm was an example of good strategic logistics capabilities and lack of the ability to properly execute operational logistics. Almost 25 years after Vietnam as the US military executed Operations Desert Shield and Desert Storm, *iron mountains* reappeared because of the requirement to have 60 days of supply for all combat forces prior to launching the attack.[5] Sustainment was also an issue for Desert Storm and was based on "…a push system that tried to push too much into Saudi Arabia too fast, and almost splintered it. Military Airlift Command went from 100 to 115 outloads at 35 locations in the US to 3 offload sites in Saudi Arabia."[6] It goes without saying, theater logistics hampered the warfighter.

Desert Storm also saw the first employment of the Joint Movement Center (JMC) where it was responsible to the combatant commander for theater logistics. According to

JP 4-01.3, *Joint Tactics, Techniques, and Procedures for Movement Control*, the JMC "should coordinate the employment of all means of theater transportation (including that provided by allies or the host nation) to support the concept of operations … and is the combatant commander's single coordinator with USTRANSCOM for intertheater movements."[7] The JMC was created to fix the seam between strategic and theater logistics, but was unable to do this during Desert Storm and is still today an organization created for the execution of Joint movement control, but not properly staffed and equipped to manage current theater logistics.

Present Day Logistics and the Creation of the CDDOC

In comparison to Desert Storm, when Operation Iraqi Freedom (OIF) was executed in March of 2003, the US military had made no major changes to doctrine, organization, personnel, and training relative to theater logistics support. It was better at strategic intransit visibility (ITV) and had prepositioned stocks, but still relied on the ad hoc-manned JMC to handle theater logistics. Logistically, it had not transformed. However, the way OIF was fought was transformational and unlike the previous Gulf War. To execute OIF and future wars, US forces would rely on speed, maneuver, and Joint or combined operations to mass effects versus massing forces. Instead of the 60 days of supplies on hand for Desert Storm, 5 to 7 days of supplies were on hand for OIF.[8]

The Secretary of Defense decision to cut the force structure for OIF by half, only 4 months prior to execution, caused the military to scrap the time-phased force deployment data used to identify the arrival schedule of forces required, with the support forces taking the brunt of that cut.[9] In the end, the US had a smaller theater logistics footprint providing support to a fast moving military force that covered two-thirds of the distance from the Iraq-Kuwait border to Baghdad (300 miles total) in only 36 hours, and eventually reached the capital 10.5 days later.[10] The Army's review of logistics during OIF summarizes logistics lessons learned. "The present supply system, while significantly more efficient than that which existed a decade earlier during the first Gulf War, lacks the flexibility, situational awareness, communications capacity and delivery means to fully meet the challenges of this new way of warfare with a reduced in-theater footprint."[11] After action studies pointed out that logistics during OIF and its play in the war's outcome "stemmed more from luck than design."[12]

Using logistical luck is not a strategy to "rapidly and decisively project power at great distances against all manner of adversary anywhere in the world."[13] The Secretary of Defense attacked the logistics problem head-on. On 16 September 2003, he designated the commander of USTRANSCOM as the distribution process owner and charged him with responsibility to "direct and supervise strategic distribution and synchronize all participants in the end-to-end supply, transportation, and distribution pipeline."[14] The USTRANSCOM Commander was given the overall responsibility to ensure that *stuff* made it from point of origin to point of consumption in order to support the theater warfighter.

Based on the historical analysis previously provided and a look at OIF logistics, it is not hard to realize the part not working in the US end-to-end logistics system was a part over which USTRANSCOM had very little control. USTRANSCOM's main task was to help the regional combatant commanders fix the theater

Article Highlights

concept, with doctrine to guide its employment, personnel properly trained and equipped, and leadership to direct and educate throughout the growth of this weapon system is a great start toward a Joint theater logistics capability.

Article Acronyms

AFSC - Army Field Services Command
AMC - Air Mobility Command
AOC - Air Operations Center
APOD - Aerial Port of Debarkation
AOR - Area of Responsibility
C2 - Command and Control
CDDOC - CENTCOM Deployment and Distribution Operations Center
CFLCC- Combined Force Land Component Command
CJTF - Combined Joint Task Force
XDDOC - Deployment and Distribution Operations Center
DDS - Defense Distribution System
DLA - Defense Logistics Agency
DoD - Department of Defense
ITV - Intransit Visibility
JFLCC - Joint Force Logistics Component Commander
JOPES - Joint Operations Planning and Execution System
JMC - Joint Movement Center
JP - Joint Publication
OIF - Operation Iraqi Freedom
POD - Port of Debarkation
SOW - Statement of Work
TAV - Total Asset Visibility
TMA - Traffic Management Agency
USCENTCOM - United States Central Command
USTRANSCOM - United States Transportation Command

logistics process by mending the seam between strategic and operational logistics.

To solve this problem, USTRANSCOM helped create the USCENTCOM Distribution and Deployment Operations Center (CDDOC). The CDDOC would be staffed with logistics professionals possessing the appropriate skill sets and would have reachback capability to the continental United States. The CDDOC gives USTRANSCOM an input to theater logistics and provides the theater commander with resources to help solve logistics at the operational level. On 12 December 2003, USCENTCOM approved USTRANSCOM's concept for a CDDOC, and the CDDOC was deployed in early 2004 for Spiral 1 of the new pilot program.[15]

What is the CDDOC?

The CDDOC was created to link strategic deployment and distribution processes to operational and tactical functions in support of the warfighter, with the ultimate goal of improving logistics from the point of origin to the point of consumption.[16] In order to do this, the CDDOC is staffed with members from USTRANSCOM, Joint Forces Command (Joint deployment process owner), Defense Logistics Agency (DLA), Army Material Command (ArmyMC), Air Mobility Command (AMC), Joint Munitions Command, Army Field Services Command (AFSC), and the individual Services. Discussions between USTRANSCOM J-3, USCENTCOM J-4, and DLA G-4 created a CDDOC mission statement.

> Confirm CENTCOM deployment and distribution priorities, validate and direct CFACC [Combined Force Air Component Commander] intratheater airlift requirement support to components and CJTFs [combined Joint task force], monitor/direct CFLCC [Combined Forces Land Component Command] intratheater surface distribution support to components/CJTF's, adjudicate identified CENTCOM distribution and intratheater shortfalls, coordinate for additional USTRANSCOM support, provide TAV and ITV for intertheater and intratheater forces and materiel, and set the conditions for effective theater retrograde.[17]

So, what is the difference between the CDDOC and the USCENTCOM JMC? The CDDOC is collocated with the CFLCC at Camp Arifjan, Kuwait and integrated into the JMC with tactical control provided by the USCENTCOM J-4. JP 4-01.3, *Joint Tactics, Techniques, and Procedures for Movement Control,* defines the mission of the JMC: "The JMC is in charge of movement control in the theater" and "must plan, apportion, allocate, coordinate, and deconflict transportation, as well as establish an ITV system to assist in tracking theater movements."[18] Based on the mission statements, the purpose of the CDDOC and JMC is essentially the same. The difference is that the CDDOC brings personnel with the correct skill sets and information technology to execute reachback to better perform strategic to operational synchronization in deployment, sustainment, and distribution of resources to the warfighters. In the author's opinion, the CDDOC properly staffs the JMC to perform its defined functions in a theater of war.

Evaluation of the CDDOC Spiral 1

> *US logistics systems can track all shipments and deliveries from the United States to overseas port of debarkation. But it lacks full "factory-to-foxhole" visibility of the supplies once they enter a theater of war. That visibility is essential in today's battlefields. The point of failure is at the seam between the strategic and operational level.*
>
> **—Lt Gen Gary H. Hughey**
> **Deputy Chief US Transportation Command**

What Worked

The *CDDOC Spiral 1 After Action Report* provides insight into CDDOC initiatives that are working to improve end-to-end logistics for the warfighter. Prior to the CDDOC's standup in the USCENTCOM area of responsibility (AOR), the USCENTCOM commander and his component commanders were continuously frustrated by the lack of visibility and oversight of forces deploying to the theater. This was primarily a problem because the lack of visibility did not give enough lead time to proactively posture to accept forces, but required commanders to react after forces arrived. Once again, forces could be efficiently and effectively deployed from the aerial port of embarkation to the aerial port of debarkation (APOD), but the coordination for follow-on movement (a Joint movement request) did not occur until after arrival at the APOD. This created unnecessary delays at the APOD and forced a reactionary measure versus proper planning.

This problem was solved through a CDDOC initiative called *Single Ticket*. Single Ticket enforces a single Joint Operation Planning and Execution System process for all passenger movements, across strategic and theater action agencies, and eliminates redundant tasks."[19] Not all forces are able to move via Single Ticket, but those that do, "move directly through strategic into theater lift and to the final destination while providing total visibility of the forces and reducing loiter time at interim locations…" A measure of the improvement after Single Ticket was initiated is that loiter time at interim locations was reduced by over 200 percent.[20]

In addition to improved force deployment, CDDOC was responsible for two initiatives that aided delivery of cargo. The first centered on intermodal diversion of cargo pallets. In this case, when direct delivery via airlift to Balad was unavailable due to higher national priorities, cargo was diverted via commercial air to Kuwait and then moved via truck to the theater distribution center where it was processed for movement via convoy north to Balad. The CDDOC synchronized and metered cargo flow to accommodate ground movement constraints. Cargo movement from Kuwait to Balad averaged 2.6 days, ensuring timely delivery of priority cargo.[21] The second cargo initiative was *Pure Pallets.* This initiative centered on the realization that it was better to wait a couple of extra days to build pallets at the depot or aerial port of embarkation, instead of using break-bulk/sort/distribution operations in the field.[22] Once again the CDDOC assisted this process with oversight and synchronization.

In addition to helping provide more efficient and synchronized theater airlift, the CDDOC was responsible for helping save money throughout the theater distribution process. The biggest money saver came through helping USCENTCOM logistics better manage its vast number of commercial containers used to distribute and store supplies throughout the theater. "When the CDDOC arrived in theater, it identified 23 sources for container data, thousands of containers missing from the ITV system, and detention charges accruing at $15M per month."[23]

The carrier owned containers were being used, in locations that lacked permanent infrastructure, as storage facilities, protective barriers, brigs/stockades, and sometimes as temporary base exchanges. The CDDOC was able to help synchronize container reporting and merge the multiple sources of container data. After collecting the concerns of all theater container managers, the CDDOC helped develop a statement of work (SOW) and standard operating procedures for better contractor execution and monitoring of containers throughout the USCENTCOM AOR.[24]

Containers were not the only theater distribution resource needing better management. The backbone of airlift logistics, 463L pallets and nets, needed some *attention to detail* to improve theater logistics and the overall Defense Transportation System (DTS). Much like the containers, there was insufficient visibility, control, and maintenance of 463L pallets and nets throughout the USCENTCOM AOR.[25]

The CDDOC implemented a Web-based AOR tracker by modifying existing Air Mobility Command software that facilitates pallet and net asset tracking. The program "enables pallet and net monitors within the AOR to report assets on hand in relation to authorizations."[26] Because the system was Web-based, visibility for all concerned parties was increased, which led to more effective and responsive asset management—over 6,000 pallets and 11,000 nets were returned to the DTS.[27]

Along with better net and pallet management, the CDDOC also was responsible for helping to ensure better maintenance of these assets. Dirty pallets and nets will clog the logistics system much like dirt in a pipe can clog or slow the flow of water through that pipe. The CDDOC drafted a SOW to establish a contractor-operated pallet and net cleaning service. This was a first of its kind SOW and allowed pallets and nets to be consolidated at central locations and cleaned and prepared by local contractors for return to the DTS. This relieved the cleaning burden from the overworked and undermanned aerial ports staffs, allowing them to improve and provide better port service.[28]

Another first of its kind was the CDDOC's testing of the Talon Reach Iridium device. The Talon Reach Iridium device is a tracking device attached to surface logistics movements to provide real time location and cargo manifest data. The CDDOC was able to bring together all the required players to carry out this test, and during a 2-day test successfully tracked priority cargo, location, and content without any user intervention.[29] This kind of TAV and ITV is a key ingredient in creating a Joint theater logistics system.

By providing personnel with the correct skill sets and reachback capability, the CDDOC was better able to synchronize and direct theater logistics than had been the case with the JMC. Many of the CDDOC's Spiral 1 initiatives were successful, but there is still a long way to go to reach the goal of true Joint theater logistics.

Problems Still Persist

Based on all written accounts of Spiral 1, the CDDOC was successful at achieving its four primary goals of improving theater asset and intransit visibility for forces and supplies, synchronizing strategic and operational distribution systems, developing performance measures, and focusing on container and air pallet management and accountability.[30] The CDDOC was successful to the point that other geographic combatant commanders are establishing XDDOCs. Although CDDOC Spiral 1 achieved its goals, there are still problems that persist.

In the author's opinion, the number one overarching issue that still persists throughout the theater logistics system is customer confidence. When customers have problems acquiring needed supplies, they attempt workarounds that may do more harm than good in relation to the theater distribution system. The customer may order twice the quantity required, or resubmit an additional requisition. In addition, the customer's immediate theater supplier, in an attempt to *better* support a unit, may go into a *push* mode by sending more than required or items not requested. This type of logistics cannot support warfare that requires units to be light, lethal, and very mobile. For a unit to have confidence in the logistics system, the supplies they request must arrive in a timely manner or they must have accurate and up-to-date information on supply status, in order to continue, or alter operations accordingly.

In the author's opinion, to begin to improve customer confidence, one must begin by solving the problem of theater intransit visibility. JP 4-01.3, *Joint Tactics, Techniques, and Procedures for Movement Control* defines intransit visibility as: "The ability to track the identity, status, and location of Department of Defense units, and nonunit cargo, and passengers; medical patients; and personal property from origin to consignee or destination across the range of military operations."[31] ITV allows the customer to monitor requests and plan accordingly, but it also allows more efficient use of theater distribution assets. The capability for logisticians to locate and track, in real time, over two-thirds of strategic logistics destined to a theater such as USCENTCOM's exists, but once it arrives in theater much of this visibility is lost.[32] The CDDOC has helped improve ITV for the theater, but improvements are needed in order to create better customer confidence in the theater logistics system.

The CENTCOM Deployment and Distribution Operations Center was created to link strategic deployment and distribution processes to operational and tactical functions in support of the warfighter, with the ultimate goal of improving logistics from the point of origin to the point of consumption.

A Joint theater logistics system with complete theater ITV must have *one boss that speaks and enforces* for the good of all. The current logistics system, and something the CDDOC struggled with, is a logistics system too stovepiped for today's warfare. The Army's logistics chief, Lieutenant General Claude V. Christianson, accurately described this condition.

> When the Army, Navy, Air Force, and Marines work side-by-side in the same region, as they did in Iraq, the combined supply system is a clashing mismatch of different cultures, incompatible communications systems, different stock numbers for similar items, even different vocabularies. Keeping track of a spare Marine Corps tank transmission as it moves from a Marine Corps depot to an Air Force cargo plane to an Army truck, for instance, is one of our biggest challenges.[33]

In its statement on command relations and directive authority during its pilot test, the *CDDOC Spiral 1 After Action Report* shows how the Services remain very parochial and stovepiped in theater logistics.

> …although CDDOC had directive authority for intratheater airlift, it was never provided with official 'directive authority' over theater surface transportation resources and assets that would have helped to synchronize the inbound and outbound cargo and passengers. The directive authority over those transportation assets rested with the CFLCC C-4, and the 143d Transportation Command.[34]

The two main publications for theater logistics are JP 4-01.3, *Joint Tactics, Techniques, and Procedures for Movement Control*, and JP 4-01.4, *Joint Tactics, Techniques, and Procedures for Joint Theater Distribution*. The primary change to these documents would be to incorporate the XDDOC concept and organization as a replacement for the JMC.

Not only are there stovepipe and compatibility issues within the logistics community, but the community also has compatibility issues with the warfighters it supports. Retired Vice Admiral Arthur K. Cebrowski, director of the Pentagon's Office of Force Transformation, described this dysfunction. "Supply problems in Iraq resulted, in part, because logisticians use separate information and command and control systems apart from those that the warfighters use."[35]

To successfully continue to transform the US military into an expeditionary Joint force, theater logistics capability must be simultaneously transformed. The CDDOC concept is a good start at improving theater logistics, but in order to provide the customer confidence required to fight today's wars, theater logistics must provide complete intransit visibility and speak coherently to the warfighters with one voice.

Upgrading Theater Logistics

Forget logistics and you lose.

—Gen F. M. Franks Jr, USA

XDDOC as a Joint Weapon System

The US military has done well at placing emphasis on strategic logistics. What it has not done is place that same emphasis and importance on theater logistics. Historically, the US military has a record of waiting until a contingency erupts to produce a theater logistics operation that gets the job done. It was not until 2 years into the Vietnam War that an attempt was made at Joint oversight of theater logistics with the TMA. Then it was not until Desert Storm that the JMC was employed to try to improve on the TMA. In the author's opinion, creation of the CDDOC is a result of inadequate performance by the JMC and theater logistics. If we fail to improve on the CDDOC initiative, the US military will continue to fight at less than its full potential.

When looking for models that could provide an example of how to upgrade the CDDOC and theater logistics, one only has to look to what the Air Force has done in making the air operations center (AOC) a weapon system in order to improve command and control of airpower. A spin-off of the CDDOC Spiral 1 was the creation of an XDDOC that could be used as an organizational concept for other theater areas of responsibility. The XDDOC is scalable, based on the requirement for each theater or contingency, and it is built around the *core* of a properly staffed JMC. The current problem is that geographic combatant commanders all have JMC Joint manning documents, but when they standup for a contingency, the JMC is never fully manned and many times the personnel deployed require additional training to be fully mission capable.[36] Originally the AOC had much the same problem when it would standup for a contingency, until the Air Force categorized it as a weapon system and placed the proper emphasis on the AOC being able to perform its wartime mission. As an Air Force weapon system, the AOC is much like an F-16 with standard training, equipment, and manning for all personnel qualified to employ or maintain it. Treating the XDDOC as a weapon system provides a scalable organization that can be properly resourced to provide required logistics and ensure customer confidence.

DOTMLPF

It takes more than just calling something a weapon system in order to produce results. When creating a new weapon system, it is important to look at it across the full spectrum of all that goes into making it a working reality. One way to analyze possible upgrades to theater logistics through the XDDOC is to look at

doctrine, organization, training, material, leadership/education, personnel, and facilities (DOTMLPF) for the XDDOC, and what it requires to provide Joint theater logistics. Looking at the XDDOC through these lenses will allow one to see some of the associated problems, issues, technology, management, and implementation opportunities associated with successfully employing such an organization to manage and control Joint theater logistics.[37]

Doctrine

US Joint doctrine for logistics provides direction for creating and operating Joint theater logistics and would require only slight changes to include the XDDOC concept. The two main publications for theater logistics are JP 4-01.3, *Joint Tactics, Techniques, and Procedures for Movement Control*, and JP 4-01.4, *Joint Tactics, Techniques, and Procedures for Joint Theater Distribution.* The primary change to these documents would be to incorporate the XDDOC concept and organization as a replacement for the JMC.[38] Other logistics doctrine will need to be updated to integrate the XDDOC concept. Incorporating the XDDOC concept would have ripple effects throughout all publications that support the US military logistics system.

Organization

The XDDOC concept creates an organization properly staffed to perform the duties of a JMC. This new organization brings in personnel with the appropriate skill sets and reachback capabilities to properly manage theater logistics. The changes to the original JMC structure are minor, but the emphasis will be on the organizations that will be required to provide deployable personnel to the XDDOC as it is stood up and expands based on the contingency.[39] National partners required to provide personnel include USTRANSCOM, JFCOM, DLA, ArmyMC, AMC, JMC, AFSC and the individual Services. These national partners will require personnel trained and capable of deploying to multiple theaters that might standup an XDDOC. Organizational change will be more of a burden on the national partners than the combatant commanders.

Training

Training to support the XDDOC concept, much like the burden of organizational change, will reside with the national partners to ensure they have personnel trained to support an XDDOC throughout all possible theater AORs. An XDDOC weapon system would support that training effort. Much like learning to maintain or employ any weapon system, the XDDOC weapon system would have commonality that would allow anyone trained on the basic version to quickly adapt and operate an upgraded system. Looking at how personnel are trained to operate the AOC weapon system could provide insight into training XDDOC personnel.

Material

The three tenants of theater distribution are visibility, capacity, and control.[40] Until complete visibility and control exists, actual capacity is not known and there is a good chance the capacity available is not being used efficiently. Looking at the XDDOC's current ability to control theater logistics highlights the need to upgrade command and control (C2) systems. As previously discussed, the theater logistics C2 systems do not *speak* the same language as the warfighter's command and control system, making C2 less efficient. Along with C2 issues, problems exist with the information systems that provide ITV. JP 4-01.4, *Tactics, Techniques, and Procedures for Theater Distribution,* dated August 2000, discusses intransit visibility and states:

> "Technologies exist today that provide the capability to conduct continuous near-real-time tracking of logistic assets. This visibility is provided through the use and implementation of commercial off-the-shelf technology known, in commercial industry, as movement tracking system."[41]

If the technology existed in 2000, it begs the question, where was the robust capability to track theater logistics in 2005? To create the XDDOC weapon system, Joint logistics systems to command and control, distribute, and monitor theater logistics must be purchased or developed. This must include satellite allocation and enough bandwidth to provide C2 and ITV down to the unit level. It also is important to recognize that waging war often extends beyond pure Joint operations and must include the purchase of systems that can expand and grow to support allies and coalitions.

Leadership/Education

Leadership and ownership of XDDOC is essential in order to ensure it is properly staffed and equipped. This is key for it to grow to a level comparable to the AOC weapon system. Based on the Secretary of Defense designating USTRANSCOM as the distribution process owner, and charging it to ensure efficient and effective solutions for synchronizing the distribution of resources from point of origin to point of consumption, USTRANSCOM would be a logical choice to be the owner of the XDDOC weapon system. Education concerning the capabilities and requirements to support the XDDOC will be another important action for USTRANSCOM.

Personnel

The personnel issue is at the heart of the problem. Previously, the organization charged with oversight of theater logistics has been staffed ad hoc, *out of hide*, and with *warm bodies*.[42] It was only after USTRANSCOM was designated the distribution process owner and the CDDOC was created that an organization was staffed with personnel capable of providing theater logistics oversight. The personnel issue for the future is to ensure trained personnel are assigned to positions on the combatant commander's staff in order to make up the core of an XDDOC. In addition, the national partners who provide personnel to round out the XDDOC must maintain trained and deployable personnel to meet potential contingencies. It will be essential to create a Joint manning document to ensure everyone is on the same *play sheet* and knows who provides what when it comes time to expand the XDDOC for contingency operations.

Facilities

Because an XDDOC could standup in a variety of infrastructure environments (theaters range from immature to very mature), facilities need to be mobile and deployable to all geographic areas of responsibility. Much like the Air Force's AN/USQ-163 Falconer AOC weapon system, creating enough XDDOC weapon systems for every geographic combatant commander would provide the basic facilities to standup an XDDOC.

Conclusion

Strategy is to war what the plot is to the play; Tactics is represented by the role of the players; Logistics furnishes the stage management, accessories, and maintenance. The audience, thrilled by the action of the play and the art of the performers, overlooks all of the cleverly hidden details of stage management.

— Lt Col George C. Thorpe
Pure Logistics, 1917

Theater logistics from World War II to OIF is replete with examples of overlooking *all the cleverly hidden details of stage management* involved in theater logistics. In World War II, the breakout from Normandy, during Operation Overlord, was held back because of the inability to move resources through the theater logistics pipeline. Korea and Vietnam were examples of the capability to push supplies to theater APODS and sea ports of debarkation, but then an inability to move the *iron mountains* and get the *right stuff* to the *right place* at the *right time*. Iron mountains reappeared during Desert Storm and the JMC concept was employed to fix the theater logistics issue. Desert Storm was successful, and the inadequate results of JMC efforts to direct theater logistics were overlooked until post OIF analysis of the US military's ability to perform Joint theater logistics. This analysis showed a logistics system that was not the force enabler required for today's lean, lethal, and mobile military.

The US military is transforming, but the transformation to get resources the *last tactical mile* remains unsolved. High-level interest, with an eye on Joint theater logistics, occurred when Secretary of Defense Rumsfeld designated USTRANSCOM as the distribution process owner with overarching responsibility for ensuring delivery of supplies from point of origin to point of consumption—factory to foxhole. In order to carry out this responsibility, the commander of USTRANSCOM proposed the DDOC concept and, with the concurrence of USCENTCOM, deployed the CDDOC to Kuwait as a pilot program in January 2004.

The CDDOC was staffed with personnel armed with information technology and reachback capability that could link the strategic deployment and distribution process to theater logistics in support of the warfighter. The CDDOC merged with CENTCOM's JMC to create an effective team in support of theater logistics. Many of the CDDOC initiatives were very successful.

The XDDOC concept is not a panacea, but does provide great promise toward improving theater logistics. Although the CDDOC Spiral 1 was very successful, problems still persist due to the lack of total ITV and absence of a C2 structure that worked logistics hand-in-hand with the warfighter. Creating a Joint weapon system out of the XDDOC concept, with doctrine to guide its employment, personnel properly trained and equipped, and leadership to direct and educate throughout the growth of this weapon system is a great start toward a Joint theater logistics capability. The next step in a long-term vision might be to look at a Joint Force Logistics Component Commander (JFLCC). A JFLCC, with oversight and decision authority at the component level, could ensure that the XDDOC weapon system is properly employed and a warfighting enabler. The XDDOC weapon system with up to date ITV technology and an upgraded C2 system will mend the seam between strategic and operational logistics and help provide a way ahead to Joint theater logistics.

Creating a Joint weapon system out of the XDDOC concept, with doctrine to guide its employment, personnel properly trained and equipped, and leadership to direct and educate throughout the growth of this weapon system is a great start toward a Joint theater logistics capability.

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18. Joint Publication 4-01.3, III-3.
19. USCENTCOM Deployment and Distribution Operations Center, 9.
20. USCENTCOM Deployment and Distribution Operations Center, vi.

21. USCENTCOM Deployment and Distribution Operations Center, 9.
22. USCENTCOM Deployment and Distribution Operations Center, 10.
23. USCENTCOM Deployment and Distribution Operations Center, vi.
24. USCENTCOM Deployment and Distribution Operations Center, 11.
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Logistics Stuff—Five Things to Consider

- **The operations/logistics partnership is a target for our enemy—protect it.** We must try always to think of an enemy's looking for the decisive points in the partnership. What we want to make strong, they will try to weaken. Where we want agility, they will want to paralyze us. What we can do to our enemy, we can do to ourselves by lack of attention. So all concerned with operations and logistics must protect and care for the partnership and the things it needs for success. This includes stuff and information and people. Also, we must not forget the corollary is just as important: the operations/logistics partnership of the enemy is a target for us; we must attack it.
- **Think about the physics.** Stuff is heavy, and it fills space. Anything we want to do needs to take account of the weight that will have to be moved, over what distance, with what effort. Usually this all comes down to time, a delay between the idea and the act. If we think about the physics, we can know the earliest time, we can finish any task and we can separate the possible from the impossible. It is crucial to determine the scope of the physical logistics task early in any planning process. Planners must know how long things take and why they take that long.
- **Think about what needs to be done and when—and tell everybody.** Once we have given instructions and the stuff is in the pipeline, it will fill that space until it emerges at the other end. The goal is to make sure that the stuff coming out of the pipe is exactly what is needed at that point in the operation. If it is not, then we have lost an opportunity—useless stuff is doubly useless, useless in itself and wasting space and effort and time. Moving useless stuff delays operations. Also, priority of order of arrival will change with conditions and with the nature of the force deploying. For example, the political need to show a presence quickly may lead a commander to take the risk of using the first air transport sorties to get aircraft *turn-round* crews and weapons into theatre before deploying all the force protection elements.
- **Think about defining useful packages of stuff.** Stuff is only useful when all the pieces to complete the jigsaw are assembled. Until the last piece arrives, there is nothing but something complicated with a hole in it. It is vital to know exactly what is needed to make a useful contribution to the operational goals and to manage effort to complete unfinished jigsaws, not simply to start more. Useful stuff often has a *sell-by* date. If it arrives too late, it has no value, and the effort expended has been wasted. The sell-by date must be clear to everyone who is helping build the jigsaw, and it is important to work on the right jigsaw first. In any operation, there is a need to relate stuff in the pipelines to joint operational goals, not to single-service or single-unit priorities. It is no good having all the tanks serviceable if the force cannot get enough aircraft armed and ready to provide air cover or ensuring that the bomber wing gets priority at the expense of its supporting aircraft.
- **Think about what has already been started.** The length of a pipeline is measured in time not distance. There will always be a lag in the system. It is important to remember what has already been set up to happen later. Constantly changing instructions can waste a lot of energy just moving stuff around to no real purpose. Poorly conceived interventions driven by narrow understanding of local and transitory pain can generate instability and failure in the system.

Group Captain David J. Foster, RAF

Technology, Logistics, and Flexibility

Much in the same manner that the logistics command and control structure should be tailored to the specific theater of operations, so should the application of technology. Advanced technology should not be forced into use in an environment in which it is not well suited. Advanced technology should not be the *square peg* forced into an inappropriate situation's *round hole.* Commanders should use the most advanced technology available that is suited for the theater of operations. For example, no matter how advanced the available motorized transportation is, if the only means of transport through a mountainous area of operations is by donkey, then donkeys should be used. It would be of greater benefit to ensure the best donkeys and donkey drivers are used than to force the use of motorized vehicles in an unsuitable environment.

The fine tuning of control practices and technology to best mesh with the environment within the theater of operations is an iterative process. As more information is obtained about both the tangible and intangible factors of the environment, adaptations to existing policies and practices will need to be made. A major role of logistics is the neutralization of adverse environmental factors and the exploitation of favorable ones. As a better understanding of the environment is gained, policies and practices must be modified to best take advantage of new opportunities or defend against previously unknown adverse conditions.

An excellent measure of the soundness of existing logistics policies or practices is the speed with which they can be adapted to meet changes in the environment. The speed of change is a direct function of the flexibility of the existing logistics system. It is, therefore, of paramount concern that flexibility be a core characteristic of any logistics plan, policy, or practice. Reliance upon single sources of supply, the belief there is only one way to do something, and resistance to new ideas are key indicators of a lack of flexibility. Without flexibility, the ability to adapt slows, which, in turn, can result in an excellent logistics plan evolving into a dated, useless way of doing things. The highest degree of flexibility should be maintained in all aspects of an operation. By maintaining the highest level of flexibility, logistics policies and practices will be able to rapidly adapt to a constantly changing environment.

Richard A. Hardemon and the Editors, Air Force *Journal of logistics*
The Logistics of War: A Historical Perspective

Martin van Crevald on Technology and War

…technology and war operate on a logic which is not only different but actually opposed, nothing is less conducive to victory in war than to wage it on technological principles—an approach which, in the name of operations research, systems analysis or cost/benefit calculation (or obtaining the greatest bang for the buck), treats war merely as an extension of technology. This is not to say … that a country that wishes to retain its military power can in any way afford to neglect technology and the methods that are most appropriate for thinking about it. It does mean, however, that the problem of making technology serve the goals of war is more complex than it is commonly thought to be. The key is that efficiency, far from being simply conducive to effectiveness, can act as the opposite. Hence—and this is a point which cannot be overemphasized—the successful use of technology in war very often means that there is a price to be paid in terms of deliberately *diminishing* efficiency.

Since technology and war operate on a logic which is not only different but actually opposed, the very concept of "technological superiority" is somewhat misleading when applied in the context of war. It is not the technical sophistication of the Swiss pike that defeated the Burgundian knights, but rather the way it meshed with the weapons used by the knights at Laupen, Sempach, and Granson. It was not the intrinsic superiority of the longbow that won the battle of Crécy, but rather the way which it interacted with the equipment employed by the French on that day and at that place. Using technology to acquire greater range, firepower, greater mobility, greater protection, greater whatever is very important and may be critical. Ultimately, however, it is less critical and less important than achieving a close *fit* between one's own technology and that which is fielded by the enemy. The best tactics, it is said, are the so-called *Flaechenund Luecken* (solids and gaps) methods which, although they received their current name from the Germans, are as old as history and are based on bypassing the enemy's strengths while exploiting the weaknesses. Similarly, the best military technology is not that which is *superior* in some absolute sense. Rather it is that which *masks* or neutralizes the other side's strengths, even as it exploits his weaknesses.

The common habit of referring to technology in terms of its capabilities may, when applied within the context of war, do more harm than good. This is not to deny the very great importance of the things that technology can do in war. However, when everything is said and done, those which it cannot do are probably even more important. Here we must seek victory, and here it will take place—although not necessarily in our favor—even when we do not. A good analogy is a pair of cogwheels, where achieving a perfect fit depends not merely on the shape of the teeth but also and, to an equal extent, on that of the spaces which separate them.

In sum, since technology and war operate on a logic that is not only different but actually opposed, the conceptual framework that is useful, even vital, for dealing with the one should not be allowed to interfere with the other. In an age when military budgets, military attitudes, and what passes for military thought often seem centered on technological considerations and even obsessed by them, this distinction is of vital importance. In the words of a famous Hebrew proverb: "The deed accomplishes, what thought began."[1]

Notes

1. Martin van Crevald, *Technology and War*, London: The Free Press, 1989, 319.

The light bulb is a good example of certain components that are more likely to fail when being turned on and off than operating continuously. This phenomenon is known as *failure on demand*.

contemporary issues

Analyzing Air Force Flying-Hour Costs
Improving Base Demand Levels Using COLT

Contemporary Issues presents two analytical articles in this edition—"Analyzing Air Force Flying-Hour Costs" and "Improving Base Demand Levels Using COLT."

In the first article Captains Kevin P. Dawson and Jeremy A. Howe, project managers at the Air Force Logistics Management Agency, examine the effect decreasing average sortie duration (ASD) would have on the cost per flying hour (CPFH) for the F-15C/D. Their research also included analyzing break rates and pilot-reported discrepancies in relation to ASD.

The research found little correlation between ASD and F-15C/D break rates, suggesting most aircraft failures are dependent on the number of sorties flown, not the sortie duration.

The analysis shows the impact changing ASD would have on five modes of failure, and demonstrated CPFH would increase as ASD was decreased.

The research suggests decreasing ASD to fly either more sorties totaling the same number of flying hours, or the same number of sorties totaling less flying hours was not cost effective.

The second article outlines COLT (customer-oriented leveling technique) implementation. COLT is a relatively new system that determines Air Force base stock levels for Defense Logistics Agency–managed consumable parts. It overrides the Standard Base Supply System (SBSS) demand level for most consumable and some low-cost equipment items. The goal is to improve supply support by reducing customer back orders and wait time.

When COLT was first implemented, it used fixed adjusted stock levels (ASL) to ensure the COLT level overrides the demand level. Although using fixed ASLs worked, it took more effort to load and did not allow COLT to consider items with minimum ASLs. In early 2006, COLT switched to readiness-based leveling-type levels. This will allow COLT to eventually push levels through the Defense Automated Addressing System and include items with minimum ASLs. COLT, in theory, is superior to the SBSS demand level and has shown, in practice, to provide better results.

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Analyzing Air Force Flying-Hour Costs

Captain Kevin P. Dawson, USAF
Captain Jeremy A. Howe, USAF

Introduction

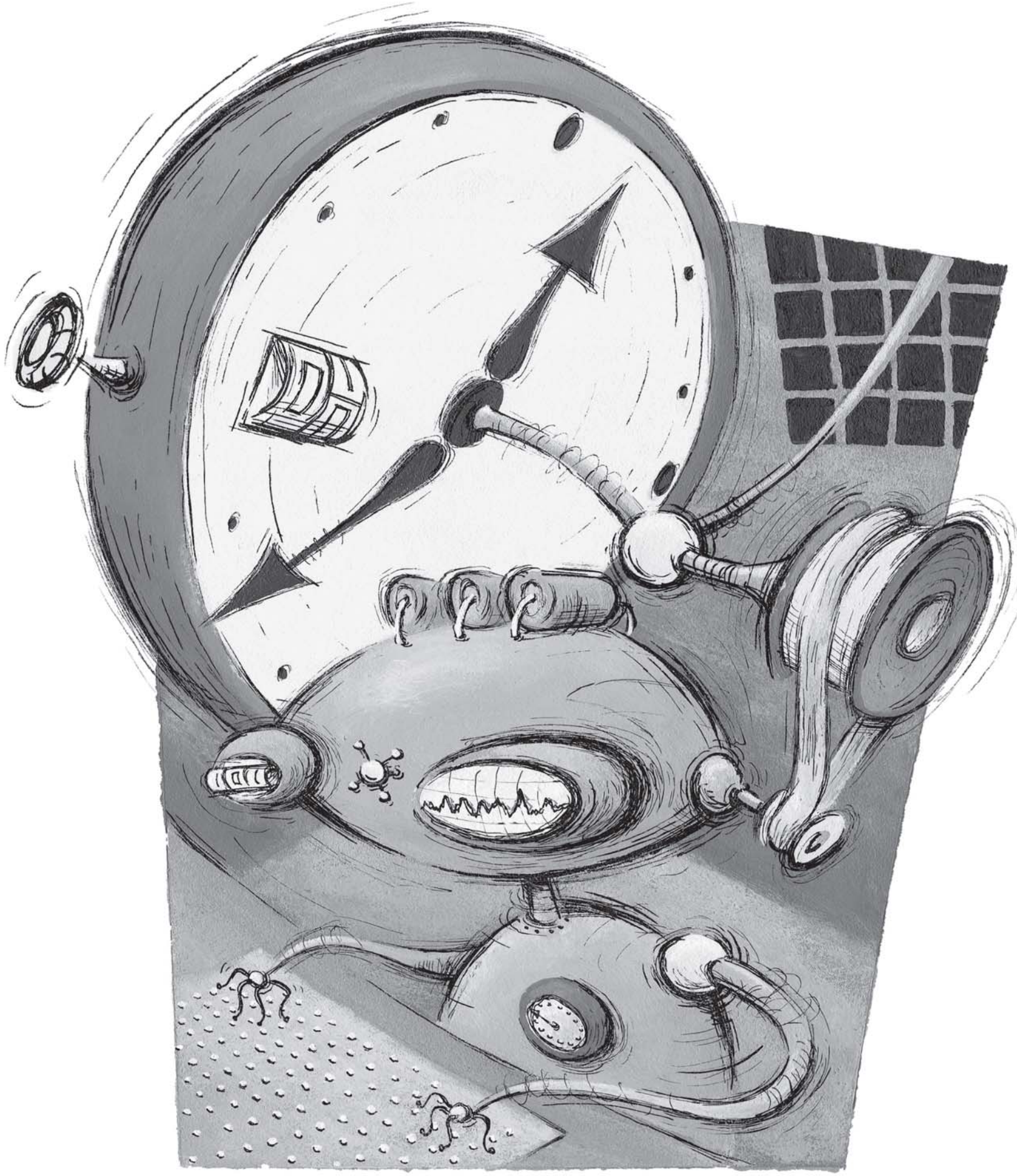
We've all, at one time or another, walked into a room and flipped on the light switch, only to hear the *pop* of a light bulb going out. In terms of wear and tear, is leaving a light turned on day and night a quicker route to failure than turning the switch on and off excessively? The light bulb is a good example of certain components that are more likely to fail when being turned on and off than operating continuously. This phenomenon is known as *failure on demand*. When Headquarters Pacific Air Forces (PACAF) asked the Air Force Logistics Management Agency (AFLMA) to evaluate the idea of flying more F-15C/D sorties at reduced average sortie duration (ASD), *failure on demand* was just one of a variety of component failure modes considered. In less than 1 month's time, the AFLMA team illustrated not only the proposed sortie duration change's impact to the cost per flying hour (CPFH), but also how varied modes of failure influence the nature of aircraft breaks.

In the end, the study team would identify five ways in which aircraft and parts fail, as well as the effect varying sortie durations have on each failure mode. The analysis indicated that CPFH will increase as ASD decreases, irrespective of the amount of sorties or hours flown. The research and findings contributed to PACAF's design of the Kadena AB F-15C/D flying-hour program. The results proved to be both rapid and beneficial, including most notably an 18 percent improvement in the mission capable rate after just 2 months time.

Background

When the study team was first approached, Kadena AB was experiencing a higher number of F-15 C/D maintenance issues than other F-15 C/D bases. For some time, mission capable (MC) rates had been approximately 20 percent lower than other F-15 C/D units, and Kadena AB had failed to meet any (all ten) Air Force F-15 C/D maintenance standards from May through June 2005.[1] With the intent of reducing an already heavy maintenance burden, Headquarters PACAF was considering the idea of reducing Kadena's F-15 C/D average sortie duration to reduce the overall number of flying hours accrued by each aircraft. However, PACAF maintenance leadership believed that reducing ASD would have a negative effect (increase) on the CPFH for Kadena's F-15 C/D fleet. In the absence of any measurable data that directly addressed this claim, the study team would need to address the following items:

- Define the CPFH model and the data used to compute hourly costs
- Identify Air Force maintenance metrics used to represent component failures
- Evaluate the factors contributing to component failure and reduced aircraft reliability
- Through statistical analysis, establish a lack of correlation between ASD and component failures



While the first three items could be accomplished through a review of existing literature and Air Force regulations, the last would require more extensive analysis. This analysis was necessary since illustrating a lack of correlation between ASD and component failures would validate the following sequence of logic:

- If component failures are not correlated to ASD, then an airframe can be expected to experience the same number of component failures per sortie, regardless of sortie duration.
- If an airframe experiences the same number of component failures per sortie, the same number of repair parts (consumable and repairable) will be required.
- If the same number of repair parts is required, the cost of parts will remain unchanged.

Once these assumptions were validated, changes in CPFH could be calculated, factoring in the following general assumptions:

- Modification costs will remain unchanged across all ASDs.
- The cost of aviation fuel will change linearly with changes in ASD. This assumption suggests that if ASD decreases by 10 percent, fuel consumption will also decrease by 10 percent and the resulting fuel costs will decrease by 10 percent. This assumption accounts for a worst-case scenario as fuel consumption will most likely not be linearly related to ASD because of the fact that excessive fuel burn is encountered during the takeoff phase of flight.
- For the purposes of valid cost comparison, paired scenarios must hold constant either the number of sorties or the number of hours flown. This is to ensure a fair comparison in the spirit of *apples to apples*. For example, it would not be valid to compare a 1.65 ASD, 500-sortie scenario (825 flying hours) with a scenario of 1.5 ASD, 600 sorties (900 flying hours).

Article Acronyms

AFLMA - Air Force Logistics Management Agency
ASD - Average Sortie Duration
CPFH - Cost per Flying Hour
PACAF - Pacific Air Forces
PRD - Pilot-Reported Discrepancies
TNMCM - Total Not Mission Capable Maintenance

$$\frac{\text{Parts + Fuel + Modifications}}{\text{Hours Flown}} = \text{CPFH}$$

Equation 1. CPFH Calculation

Analysis and Research

Kimbrough identified the three major cost variables of the aircraft CPFH calculation model to be:

- Aircraft parts
- Aviation fuel
- Modifications and sustainment costs.[2]

Aircraft part costs for each fiscal year are broken down into consumable and repairable parts; however, this research aggregated these categories to simply *aircraft parts*. Aviation fuel represents the cost of fuel used throughout the fiscal year. Modifications and sustainment costs represent planned depot modifications and weapon system upgrades. CPFH is calculated by adding the three major cost variables and dividing by the number of hours flown throughout the fiscal year. Equation 1 illustrates this calculation.

Manuel discovered that 70 percent of total aircraft flying program costs were attributed to repair parts, 19 percent were attributed to aviation fuel, and 11 percent were attributed to modifications and sustainment.[3] Assuming these ratios can be applied to strategic CPFH models across any weapon system, we are able to estimate CPFH changes based on ASD and the number of sorties flown.

Ebeling identified five different methods of inducing a failure:

- Hourly operation time
- Operating cycles
- Clock time
- Failures on demand
- Maintenance-induced failures[4]

Component failures attributed to *hourly operation time* should experience fewer failures per sortie as ASD (and the resulting total operating time) is reduced. However, if the number of *low ASD* sorties is increased to achieve the same number of flying hours as the baseline ASD, the number of *hourly operation time* failures will remain unchanged. Components failing based on an *operating cycle* failure distribution, fail based on the number of uses. Therefore, flying the same number of sorties with a lower ASD will result in approximately the same number of operating cycle failures. However, increasing the number of sorties will result in increased failures based on operating cycles. Components failing on a clock time failure distribution should experience the same number of failures regardless of ASD or the number of sorties flown.

Failures on demand may occur when a system is turned on. Sometimes referred to as the *light bulb theory*, this failure mode pertains to light bulbs and many other electrical components that

Failure Rate Distribution	Lower ASD, Same Sorties (Reduced Flying Hrs)	Lower ASD, More Sorties (Constant Flying Hrs)
Operating Hours	Less	Same
Operating Cycles	Same	Increased
Clock Time	Same	Same
Failures on Demand	Same	Increased
Maintenance Induced	Same	Increased

Table 1. Impact of ASD, Sorties Flown, and Flying Hours on Component Failures

have a higher probability of failure when activated as opposed to normal operational loads.[5] In terms of applying this failure logic to aircraft sorties, if the number of sorties remains unchanged, the number of failures on demand—in this case, electrical failures as well as physical failures incurred during the event demands of aircraft takeoffs and landings—should remain unchanged as well. It follows then, that increasing the number of sorties will yield an increased number of failures on demand. Likewise, the number of maintenance-induced failures should increase, because more maintenance is required to repair an increased number of component failures and perform additional through-flight actions. A maintenance-induced failure is defined as a maintainer damaging a component during repair. The number of maintenance-induced failures increases as the amount of either scheduled or unscheduled maintenance increases. With more sorties, maintenance will increase.

Table 1 summarizes the effect of reducing ASD with respect to the number of component failures based on the different methods of inducing failures described above.

It can be seen from Table 1 that reducing ASD only results in a lower number of component failures when the number of sorties flown remains unchanged. Increasing the number of *low ASD sorties* to achieve the baseline flying-hour program will result in an increased number of component failures for three of the five different failure induction methods.

The number of failures will remain unchanged for components failing on an operating hour distribution; therefore, these failures will not increase total aircraft operating costs for comparable flying hours. Next, it is important to identify metrics capable of providing measurable data that would allow for the examination of failures based on operating cycles, failures on demand, and maintenance-induced failures.

Of the numerous maintenance metrics tracked by the Air Force, three are of primary interest:

- Break rate
- Pilot-reported discrepancies (PRD)
- Ground abort rate

A secondary maintenance metric of interest is total not mission capable maintenance (TNMCM) time.

Aircraft break rate represents the number of Code 3 breaks divided by the total number of sorties flown.[6] A Code 3 break indicates that an aircraft has a major discrepancy in mission-essential equipment that may require repair or replacement prior to further mission tasking. The break rate is "an indicator of aircraft system reliability ... and is an excellent predictor of parts demand."[7] A sortie is considered to be one operational cycle for an aircraft at the strategic level, and break rates capture the number of grounding breaks per sortie. Break rates convey an expected number of *breaks* per operational cycle, and can supply data for components failing on an operating cycle failure distribution. PRDs can also be used as an indicator of breaks, and account for most Code 2 breaks and delayed discrepancies. A Code 2 break is one in which an aircraft has a minor discrepancy, but the aircraft is capable of further mission assignments.

When an aircrew accepts an aircraft and then encounters a grounding maintenance condition, a ground abort occurs. Basically, this scenario indicates that an aircraft subsystem did not fail until it was placed under an operational load by the aircrew. Preflights and through-flights will test most systems for operability, however many systems will be powered down until crew arrival. Therefore, ground abort rates are the most suitable data source for identifying failures on demand.

Based on the reliability theory depicted in Table 1, the number of component failures should increase as the number of sorties flown increases. The study team hypothesized that the number of failures would increase at an amount proportional to the break rate. For example, a unit flying 100 sorties with a 15 percent break rate can expect to experience 15 failures. Likewise, flying 200 sorties should then result in approximately 30 failures. As the number of sorties increases, PRDs should also increase. TNMCM time should increase as well due to the added repair actions resulting from an increased number of component failures.

A critical piece of this analysis pertained to establishing that ASD has little to no impact on the break rate and number of PRDs reported. If ASD is correlated to break rate and PRDs, we cannot safely assume that aircraft, strategically speaking, fail on a cyclical basis (per sortie), as extended sorties may induce additional wear and tear on components. However, a lack of correlation between ASD and both break rate and PRDs would validate the aforementioned assumption.

Figure 1 shows the correlation matrices for PACAF F-15 C/D maintenance data delineated by command and base. These matrices show no direct relationship between ASD and break rate, nor do they show a direct relationship between ASD and the number of PRDs. Regression analysis confirmed a lack of correlation with an R^2 value of .1851 for ASD to break rate, and an R^2 of .0079 for ASD to PRDs. Therefore, it can be said that changes to ASD are unlikely to bear witness to significant changes in break rate or the number of PRDs. In other words, while the number of breaks will increase as the number of sorties increases, the rate at which the aircraft break remains unchanged.

With the statistical analysis complete, we are able to examine and discuss the specific impact of failures to CPFH under two distinct scenarios. The first is one in which the total number of flying hours is held constant; the second is one in which the total number of sorties is held constant.

Flying Hours Held Constant

If ASD is reduced but the number of sorties is increased to maintain a desired flying-hour program, the number of *breaks* (Codes 2 and 3) will increase and the parts required to repair these breaks will also increase. The presumed increase would be linear and proportional to the increased number of breaks. Having established that the break rate remains relatively unaffected by ASD, it is valid to assume it will remain unchanged and produce additional breaks proportional to the increase in sorties flown. For this model, the assumption is that the cost of parts will increase proportionally to sorties flown. Depot modifications and equipment upgrades are planned and scheduled on a fiscal year basis, independent of sorties and flying hours. Therefore, the assumption can be safely made that the cost of modifications will also remain more or less the same over time regardless of ASD or number of sorties flown. Because the number of flying hours remains constant, we will assume the cost for fuel remains unchanged; however, we believe that, realistically, this cost should increase given the greater amount of fuel being expended during the increased number of takeoffs. Referring to equation

ELMENDORF & KADENA COMBINED

	ASD	*Sorties*	*Hours*	*NMCM*	*PRDs*	*Break Rate*	*Fix Rate*	*GA Rate*
ASD	1							
Sorties	-0.423329	1						
Hours	0.459953	0.576527	1					
NMCM	-0.045099	0.100756	0.056012	1				
PRDs	-0.089061	0.432281	0.33525	0.825703	1			
Break Rate	0.430272	-0.51202	-0.131974	0.438816	0.244312	1		
Fix Rate	0.084292	-0.039852	0.059803	-0.876954	-0.726926	-0.394789	1	
GA Rate	0.209038	-0.383863	-0.1771	0.467582	0.293111	0.455907	-0.536551	1

ELMENDORF

	ASD	*Sorties*	*Hours*	*NMCM*	*PRDs*	*Break Rate*	*Fix Rate*	*GA Rate*
ASD	1							
Sorties	-0.437363	1						
Hours	0.383377	0.639519	1					
NMCM	-0.048088	0.184529	0.144108	1				
PRDs	-0.048227	0.457789	0.423036	0.471886	1			
Break Rate	0.545413	-0.507781	-0.107503	0.047028	0.142843	1		
Fix Rate	0.086518	0.016116	0.095437	-0.533626	-0.261427	-0.083821	1	
GA Rate	0.228785	-0.3941	-0.202464	0.267789	0.131635	0.240222	-0.500488	1

KADENA

	ASD	*Sorties*	*Hours*	*NMCM*	*PRDs*	*Break Rate*	*Fix Rate*	*GA Rate*
ASD	1							
Sorties	-0.419614	1						
Hours	0.516478	0.52428	1					
NMCM	-0.118738	-0.089334	-0.150463	1				
PRDs	-0.2127	0.655179	0.436042	0.422141	1			
Break Rate	0.36924	-0.654058	-0.231923	0.543617	-0.079104	1		
Fix Rate	0.202313	0.185897	0.377599	-0.655427	-0.161726	-0.430747	1	
GA Rate	0.230726	-0.581919	-0.291922	0.49828	-0.071508	0.633967	-0.447102	1

KEY

Green Values Approaching 1
Positive Correlation

Red Values Approaching -1
Negative Correlation

Values near zero

No Correlation

Note: correlation does not indicate causality, merely that a linear trend may exist between two variables

Historical data does not indicate strong correlation between ASD and any performance measures

Figure 1. Correlation Matrices for PACAF F-15 C/D Maintenance Data

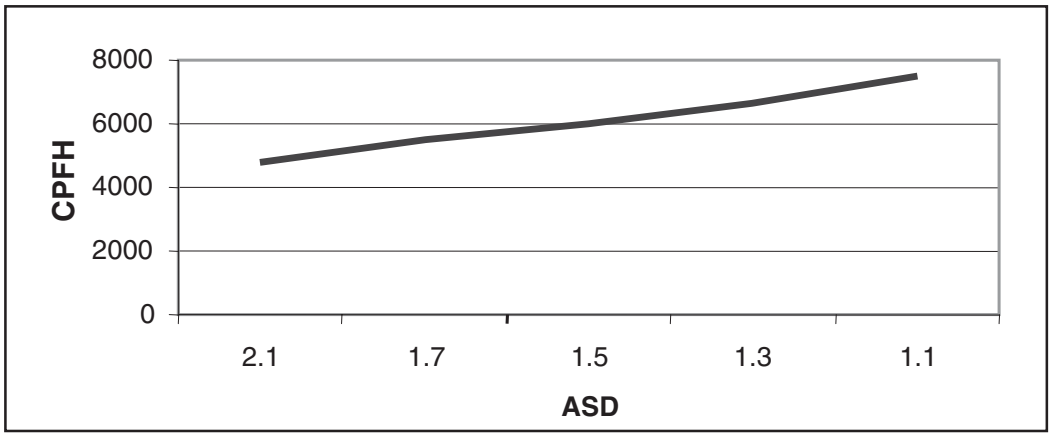


Figure 2. CPFH Estimates: Variable ASD, Variable Number of Sorties, Same Flying Hours

1, the increased cost for repair parts will raise the numerator value while all other variables (including the denominator) remain unchanged. With the numerator increasing, and the denominator held constant, we see an increase in CPFH. This model is represented in Figure 2, and although the data used in this research was notional ($6,000 original CPFH for a 1.5 ASD), the same trends are experienced regardless of the cost data used: CPFH increased as ASD was reduced.

Sorties Held Constant

If the same number of sorties is flown over different ASDs, the number of *breaks* (Codes 2 and 3) will remain unchanged and the parts required to repair these *breaks* will also remain unchanged. Furthermore, if the repair parts required remain unaffected by changes in ASD, the cost of parts should remain relatively the same. Depot modifications and equipment upgrades are planned and scheduled on a fiscal year basis independent of sorties and flying hours. Therefore, we can safely make the assumption that the cost of modifications will also remain more or less the same over time regardless of ASD or number of sorties flown. As such, when measuring the effect of ASD changes on CPFH, we can hold constant the cost of parts and cost of modifications. With reduced ASDs, it follows that we will observe reductions in quantity of fuel consumed and total hours flown. Under a worst-case scenario, we could assume a perfectly linear relationship between fuel used (and consequently, cost of fuel) and hours flown. For this model, the cost of fuel was assumed to decrease proportionally to the reduction in flying hours (for example, 10 percent fewer flying hours would result in 10 percent lower fuel costs). Realistically, more fuel is likely expended at takeoff versus level flight, but for the purposes of this analysis, we assumed a linear relationship. Since the number of flying hours is simply a manipulation of ASD (that is, the product of ASD and the number of sorties), the same logic can be applied to ASD reduction. Referring to Equation 1 under this scenario, the numerator is decreasing while

the denominator is also decreasing. CPFH will increase in this scenario as the numerator is not decreasing at the same rate as the denominator. Therefore, a direct comparison can be made between CPFH calculations for different ASDs. Due to the lack of operational data, notional cost data was used to populate the model represented in Figure 3. The numerical values of the CPFH change; however, the trend established in Figure 2 remains constant—CPFH increased as ASD was reduced.

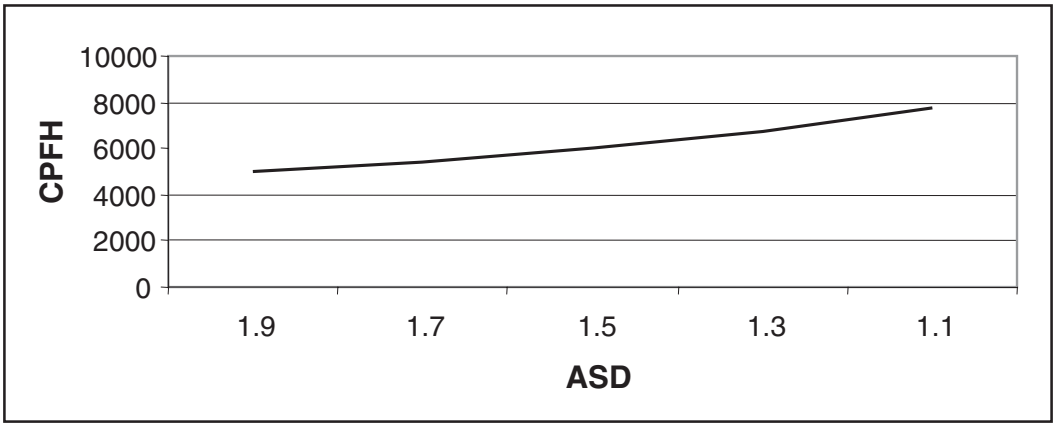


Figure 3. CPFH Estimates: Variable ASD, Same Number of Sorties, Variable Flying Hours

Conclusions and Recommendations

The findings of this research show that CPFH will increase as ASD decreases irrespective of the number of sorties or hours flown. The analysis indicates that reducing ASD cannot decrease the cost of aircraft repair parts, which accounts for approximately 70 percent of the total flying-hour program costs. Reducing ASD and pursuing the same flying-hour program increases the cost of repair parts and significantly contributes to an increased CPFH. This scenario will require more maintenance effort to generate additional sorties and will require more maintenance effort to repair the additional aircraft breaks.

Notes

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5. *Ibid*.
6 *Maintenance Metrics U.S. Air Force*, Gunter Annex, Maxwell AFB, AL: Air Force Logistics Management Agency, 20 Dec 2001.
7. *Ibid*.

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notable quotes

The onus of supply rests equally on the giver and the taker.

—General George S. Patton, Jr, USA

Logistics sets the campaign's operational limits.

—Joint Pub 1, *Joint Warfare of the Armed Forces of the United States*

Planning is everything—plans are nothing.

—Field Marshal Helmuth von Moltke

The final dictum of history must be that whatever excellence Lee possessed as a strategist or as a tactician, he was the worst Quartermaster General in history, and that, consequently, his strategy had no foundations, with the result that his tactics never once resulted in an overwhelming and decisive victory.

—Major General J. C. Fuller, USA

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Improving Base Demand Levels Using COLT

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COLT (customer-oriented leveling technique) is coming to a base near you! Starting in 2006, the Air Force began formally implementing COLT levels, causing many people to ask, "What is COLT, and what will it do for me?"

COLT is a relatively new system that determines Air Force base stock levels for Defense Logistics Agency (DLA)–managed consumable parts. It overrides the Standard Base Supply System (SBSS) demand level for most consumable and some low-cost equipment items.[1] The goal is to improve supply support by reducing customer back orders and wait time.

As shown in Figure 1, the Air Force began using COLT in fiscal year (FY) 2001 at the air logistics centers. There were several events over the next 4 years culminating in the Air Force Materiel Management Board approving COLT for Air Force-wide implementation at the end of FY 2005.

Level Setting

The basic concept for consumable items is the same under COLT as it is under the SBSS demand level (DL). Both employ a reorder point (ROP) which is the point to order stock to replenish the demand levels, and an economic order quantity (EOQ), or the minimum amount ordered. The total demand level is the combination of the two (Level = ROP + EOQ). When the number of assets on hand and due-in drops to the ROP, an order is placed for enough assets to bring the number on hand and due-in up to ROP + EOQ (see Figure 2).

The ROP should be large enough to cover demands for an item during the replenishment period, sometimes referred to as the order and ship time (OST), as well as cover variability in demands. A back order occurs when users demand more during the replenishment cycle than is on hand when the order is placed—theoretically that is the computed ROP.

COLT currently uses the same EOQ as the SBSS, but a different ROP. So, how should the Air Force set their ROPs? Why doesn't the Air Force just buy more stock? The fiscal reality is that there are never enough funds to prevent all back orders, and funds spent on one item cannot be spent on another item. Therefore, we need to determine the *right* mix of levels. COLT has proven to be both more efficient and more effective than the SBSS in determining what items to stock and the amount to stock.

The COLT ROP is different from the SBSS ROP for three reasons: its logic minimizes back orders, it considers DLA support levels, and its method considers demand variability. These differences can cause levels to be either higher or lower than the SBSS demand level (see Figure 4 later).

Cost of a Back Order/Back Order Minimization

Back orders will occur, but having a back order for a low-cost item is disconcerting. Why ground an aircraft for the lack of a 5-cent item? In fact, for the same cost of saving a single big-ticket item from back order, we can save hundreds of back orders on cheaper items. This concept of considering both back orders and cost underlies the COLT back order minimization logic.

The SBSS sets a ROP to achieve a given *fixed* level of support. For example, in Figure 3, the SBSS sets the ROP to satisfy all demands during the reorder cycle 84 percent of the time. Stated another way, the SBSS expects back orders 16 percent of the time. COLT, on the other hand, minimizes the amount of back orders for a given level of investment. So by performing this optimization, COLT is finding the levels to provide the best possible performance; SBSS does not optimize anything.

COLT asks the question, "If I have one more dollar to spend on safety levels, which item will provide the largest reduction in back orders for that dollar?" COLT increases levels incrementally in this order. This results in the fewest back orders for any given total cost.

For low-cost, high-demand items, COLT tends to stock more than the SBSS would stock (see Figure 4, left). For high-cost, low-demand items, it tends to stock less than the SBSS (see Figure 4, right). COLT is constrained to spend the same amount as the SBSS, so COLT stocks less for a few high-cost items and is then able to stock more for many low-cost items. COLT increases levels for about 89 percent of the demand, compared to the SBSS demand level, stocks the same for about 2 percent of demand, and stocks less for 8 percent of the demand.

The Replenishment Period Considering DLA Support

SBSS only considers OST for the replenishment period, as shown in Figure 3. Because OST measures the time to obtain the item from the depot—assuming the depot has the item—it ignores the instances when the depot does not have the item on hand and must obtain it from a vendor.

COLT considers expected DLA support levels (DLA issue effectiveness, DLA delay times, and DLA delay variability) as well as OST. The SBSS does not. This makes for a more accurate measure of the replenishment period, and allows COLT to select levels that are more effective.

Suppose we have two national stock numbers (NSN) with exactly the same characteristics (same demand rate, OST, and so forth), except one has good DLA support and the other does not. SBSS would give both NSNs the same level. COLT would perceive the item with poorer support (low DLA stock availability or long lead times) and realize the base requires a higher safety level (higher ROP) to cover the variability in DLA's support. Figure 5 illustrates the difference in the distribution of back orders if only the OST is used to determine levels versus when the replenishment period also considers DLA delay time. SBSS computes the ROP to satisfy 84 percent of the demand. However, because it fails to consider DLA delay time, it only satisfies 60 percent of the demand during the actual replenishment period, which includes expected DLA delay time.

Demand Variability

COLT considers the expected DLA stock availability (and delay time if there is no stock), order and ship time, average order size, and demand rate in determining demand variability. When the variability is high, the frequency of orders and the quantity requested is harder to predict. Therefore, bases must keep more on the shelf to reduce the chance of a back order. Inaccuracy with demand variability can drastically affect the number of back orders. Improperly estimating the demand variability can lead to a level that is too low, producing too many back orders (see Figure 6, right). Figure 6 shows demand is more variable (the distribution is more spread out) than the SBSS computes, so the level assuming 84 percent actually satisfies demands less than 84 percent of the time. Similarly, it can lead to a level that is too high (Figure 6, left), where funds that could better be spent elsewhere are wasted on unnecessary stock levels.

Level Setting Summary

Based on the factors discussed previously, COLT determines an item's ROP. This can result in COLT providing levels higher or lower than the SBSS demand level (see Figure 4). Although COLT does not directly compare itself to SBSS DL when assigning levels, we found at the 15 bases testing COLT, the COLT level is greater than or equal to the SBSS level for 71 percent of items and 91 percent of the demand. That is, COLT is computing more levels where they are needed most.

COLT Leveling

Optimization

COLT minimizes the base-wide customer wait time (CWT) for a given investment. It does so by minimizing the time-weighted expected back orders (EBO) for that investment. The SBSS DL system does not perform any optimization. Its formulas are designed to provide a percentage of back orders on every item, regardless of cost or demand variability. Although there are other common performance measures, such as issue effectiveness (IE) and back order days, also known as delay or conditional wait time, conditional wait time is a more complete measure.

COLT starts every item with a zero level. Even if there are demands in the system, there is no guarantee that an item will

Article Acronyms

ASL - Adjusted Stock Level
COLT - Customer-Oriented Leveling Technique
CWT - Customer Wait Time
DAAS - Defense Automated Addressing System
DL - Demand Level
DLA - Defense Logistics Agency
EBO - Expected Back Order
EOQ - Economic Order Quantity
FY - Fiscal Year
HAZMAT - Hazardous Material
IE - Issue Effectiveness
IEU - Individual Equipment
LI - Line Items
LSC - Logistics Support Center
MIC - Mission Impact Code
MICAP - Mission Capable
NSN - National Stock Number
OST - Order and Ship Time
ROP - Reorder Point
SBSS - Standard Base Supply System

receive a level. Although the criteria for receiving a positive level is different than that for SBSS, the concept that some items do not receive levels is the same. COLT finds the item that produces the largest reduction in back orders per dollar spent, called the sort value. It assigns a level to that item, then repeats this process until some preestablished target is reached. Once the overall target is reached, COLT has found the collection of levels that produce the minimum EBO for a given level of investment.

Selecting a Target

We can assign levels all day long, but we have to stop at some point. COLT uses three possible targets: obligation, sort value, and CWT.

The obligation target considers the amount of money to be spent. COLT is cost neutral, compared to the SBSS. That is, COLT uses the obligation dollars that would be spent for the remainder of the fiscal year using the SBSS levels. As COLT provides levels, it keeps track of the estimated obligations based on the COLT levels. When the COLT obligations reach the SBSS obligations, COLT stops leveling. COLT uses this method during the first run for each base to establish a baseline, thus providing *cost-neutral* COLT levels. Subsequent runs normally use the sort value obtained from the initial run.

A sort value is the reduction in back orders per dollar—the primary goal of COLT. As described earlier, COLT assigns the next level to the item with the highest sort value. As COLT proceeds, the highest sort value becomes smaller and smaller. Using a sort value target causes COLT to stop leveling when the highest sort value is less than the target. Essentially, this means we reached a point of diminishing returns—the reduction in back orders per dollar is so small it is no longer worth spending that dollar.

A CWT target works much like the sort value. As more levels are assigned, the overall CWT decreases. Once it reaches a targeted CWT value, the model stops.

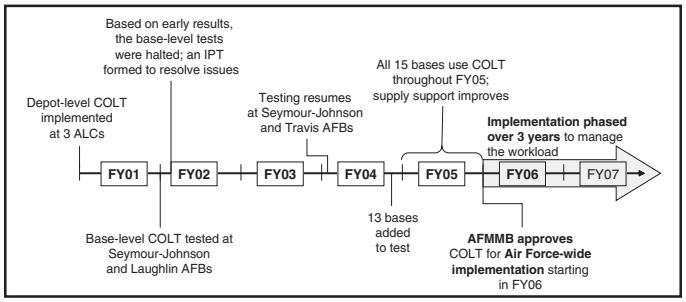


Figure 1. Timeline of COLT Development

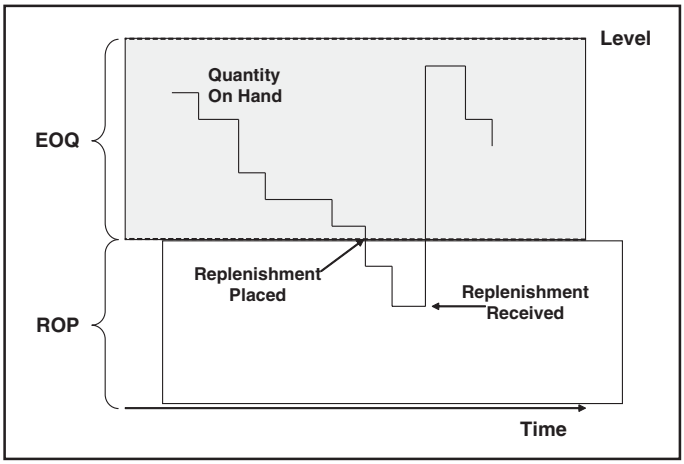


Figure 2. SBSS and COLT Leveling

Additional COLT Business Rules

To more correctly model the real world, COLT includes some additional business rules. These are the *tweaks* that make the system more accurate and useful to the end user.

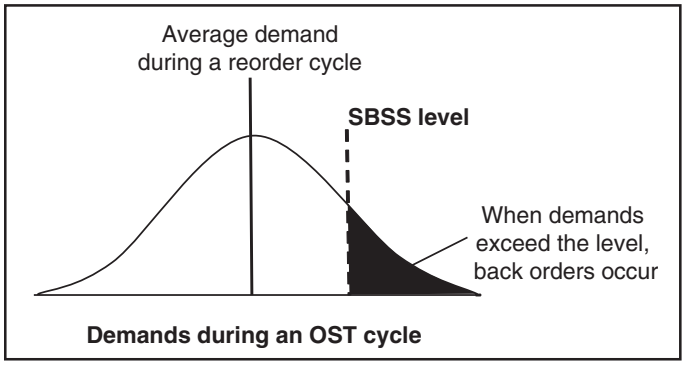


Figure 3. SBSS Leveling

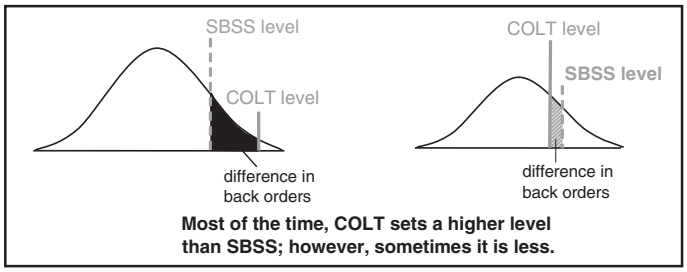


Figure 4. COLT versus SBSS Leveling

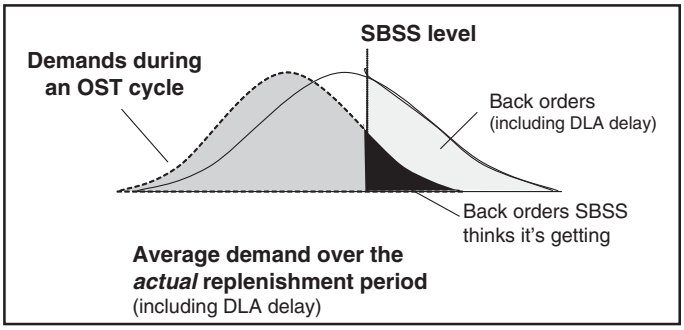


Figure 5. Difference in Back Order Distribution (OST versus Replenishment Period)

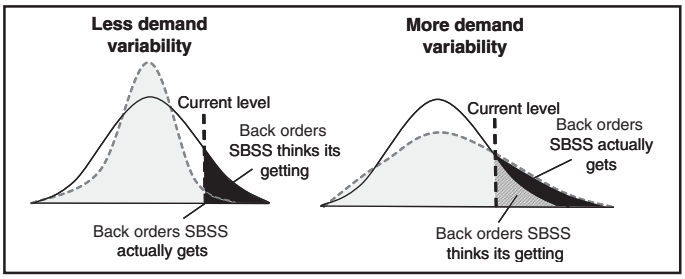
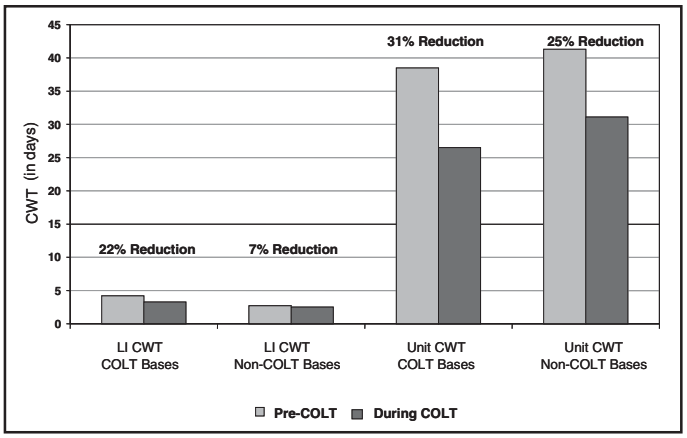
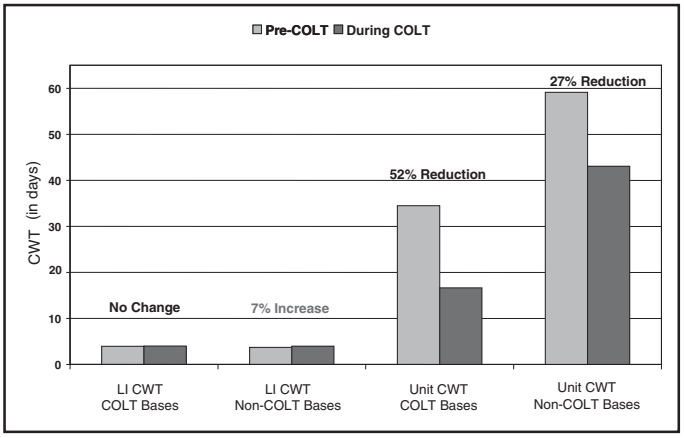


Figure 6. Inaccuracy Due to Demand Variability

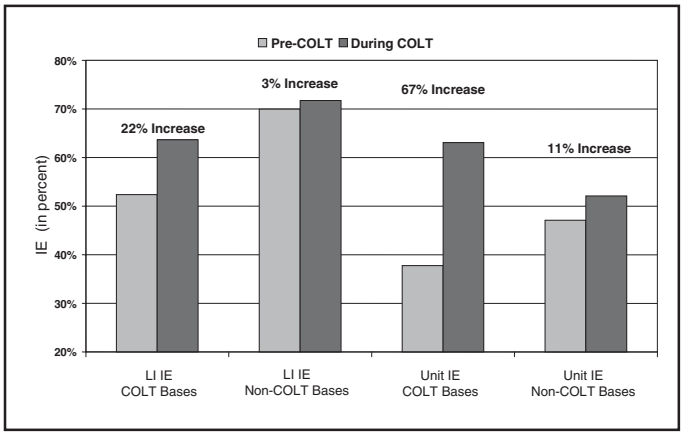


Customer Wait Time for FY04 Bases

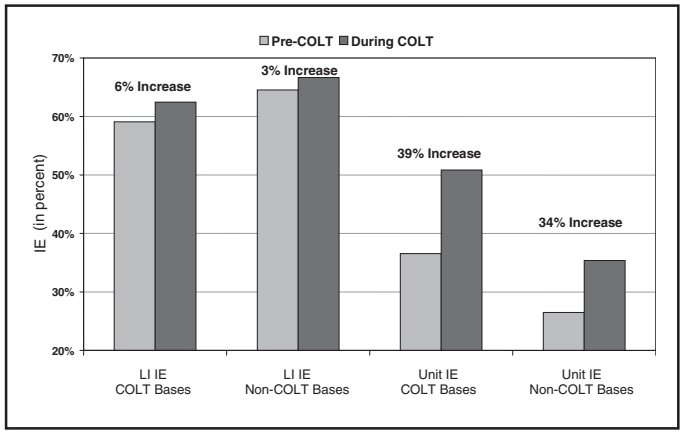


Customer Wait Time for FY05 Bases

Figure 7. Comparison of Customer Wait Time

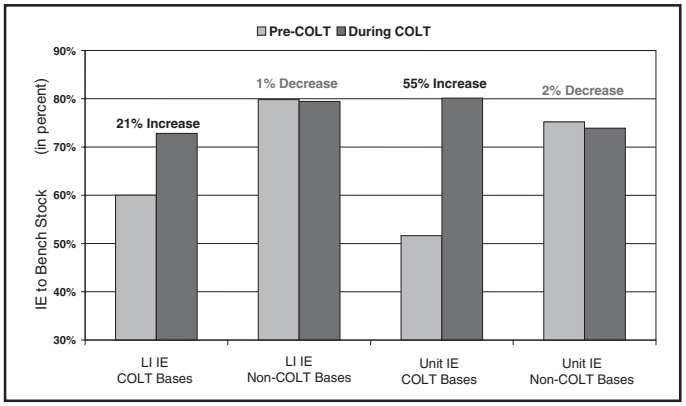


Issue Effectiveness for FY04 Bases

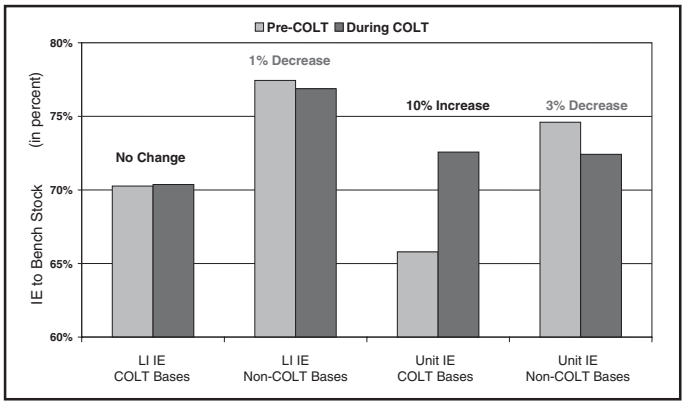


Issue Effectiveness for FY05 Bases

Figure 8. Comparison of Issue Effectiveness



Bench Stock Issue Effectiveness for FY04 Bases



Bench Stock Issue Effectiveness for FY05 Bases

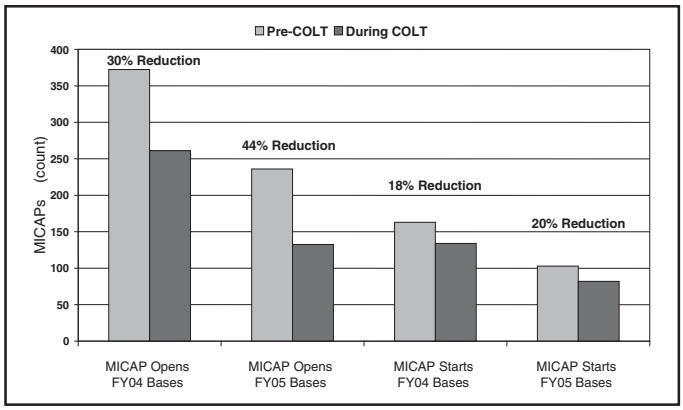
Figure 9. Comparison of Bench Stock Issue Effectiveness

Frequency of COLT Runs

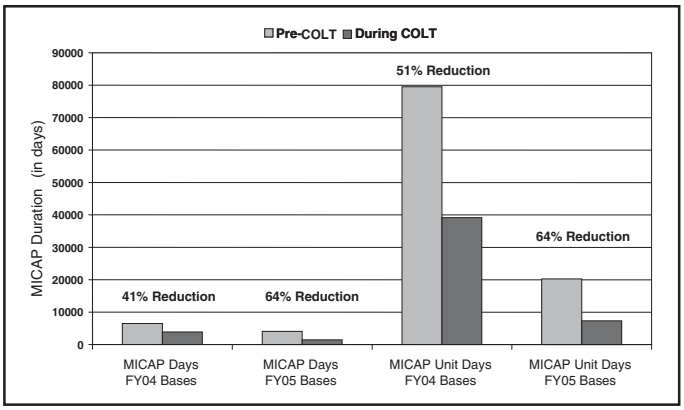
Although COLT could be run as often as desired, quarterly base runs were selected. This is sufficiently frequent to keep up to date with the base's data, but not overreact to every minor blip in demand. To spread the workload and reduce requisition spikes, about one-third of the bases are run monthly, so all are run at some point within the quarter.

Level volatility reduction

COLT is trying to find the best levels, period. Sometimes that means changing the level based on a trivially small decrease in EBOs. Although this is mathematically correct, a change of any size may require workload, requisitions, excess, and so forth. So a rule was established: the level must change by at least the square-root of the old level before COLT will provide an updated



MICAP Open and Starts for COLT Bases



MICAP Days for COLT Bases

Figure 10. MICAP Results

value. For example, if the old level is 9, COLT will only change the level if COLT computes a level either more than 12 or less than 6. The SBSS uses the same rule.

Other Inventory

Base supply (retail levels) is not the only stock available on base to satisfy user demands. Bench stock is regularly available for particular users and available to all users for back orders and for all mission capable (MICAP) parts. COLT considers some portion of the bench stock as available to reduce expected back orders. In essence, COLT *retail* levels do not duplicate the bench stock levels.

COLT Caps

The COLT ROP and EOQ are both capped at 1 year.[2] These caps forestall having too much stock. Stockage priority code 5 (SPC 5) items are capped at the existing on-hand balance. This allows COLT to maintain a level on these items, and prevents back orders, but keeps the system from buying more unless there are subsequent demands. If there are subsequent demands, the SPC code will decrease and full leveling can once again take place. The final cap calls for the total COLT level to be capped at $4,000, if DL = 0, or $5,000 more than the SBSS DL, if DL > 0. COLT will sometimes provide significantly more levels than the current DL. Although mathematically it is the proper thing to do, these caps can produce problems with shelf space, funds, and requisition rejections.

COLT Restrictions

There are particular issues with individual equipment (IEU) items (FSG 84 and FSC 4240) and hazardous material (HAZMAT) items (issue exception codes 8, 9, or M). Despite MAJCOM policies that severely restrict the stocking of these items, there are still recurring demands and SBSS demand levels for them. Reacting to demands for these restricted items, COLT will develop levels for items that some bases and major commands do not want. COLT only provides levels on IEU and HAZMAT items if the SBSS DL is greater than zero. That way, if the items did not have a level before COLT, they will not have a level with COLT.

Mission Impact Code 1

Mission impact code (MIC) 1 items are very important because they have previously caused a weapon system grounding incident (MICAP). Therefore, COLT guarantees a positive level for all MIC 1 items.

Does COLT Work?

COLT includes more information than the current system and has an optimization scheme to minimize customer wait time. Therefore, in theory, it should be better than SBSS. But does it provide better results in practice?

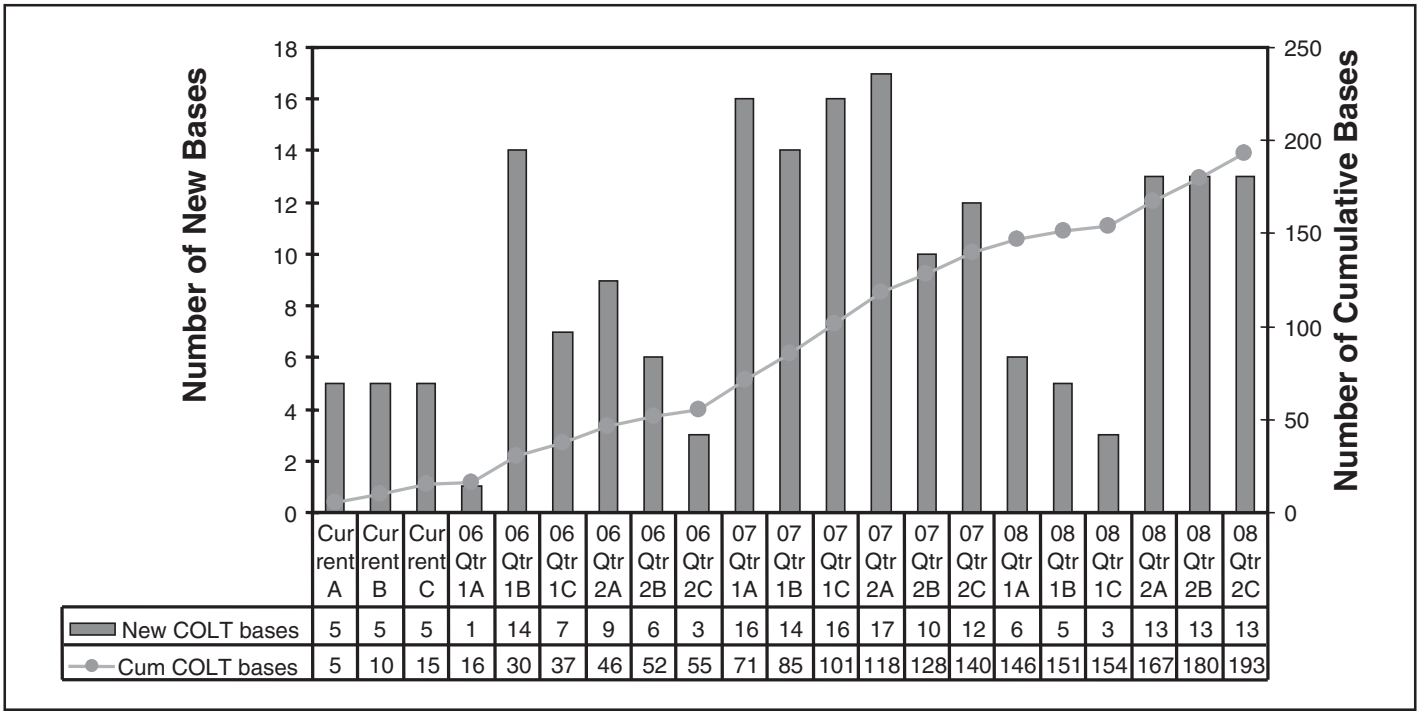
Figures 7 to 9 compare supply performance for FY04 and FY05 COLT to non-COLT bases, and Figure 10 provides MICAP data for the COLT bases. FY04 COLT bases were Travis and Seymour-Johnson. The non-COLT bases (chosen for like missions or aircraft) were Dover and Lakenheath. The FY05 bases included the remaining 13 COLT bases and 7 non-COLT bases. Pre-COLT data was taken from December 2002 to November 2003 or 2004 as appropriate, and COLT data was taken from December 2003 or 2004 until October 2005.

Figure 7 compares customer wait time for line items (LI) and units.[3] Although it is interesting that both COLT and non-COLT bases improved, the bases running COLT longer (FY04 bases) show a distinctly larger improvement than the non-COLT bases (22 percent versus 7 percent LI CWT reduction, and 31 percent versus 25 percent unit CWT reduction). The newer COLT bases also showed improvement over the non-COLT bases (no change versus 7 percent LI CWT increase, and 52 percent versus 27 percent unit CWT reduction).

Figure 8 compares issue effectiveness (IE) for line items (LI) and units. Although CWT is a more complete measure, IE is commonly used. Once again, both COLT and non-COLT bases improved; but the COLT bases improved by significantly more. This is especially seen in the unit measures.

Figure 9 compares bench stock IE for LI and units. Earlier, we stated that COLT considers part of bench stock as available to reduce back orders. That raises the concern that COLT might provide poorer support for bench stock items than prior to COLT. However, we see that the COLT IE to bench stock improved significantly for both LI and unit measures for FY04 bases and for unit measures for FY05 bases; non-COLT bases decreased slightly for all categories.

Figure 10 shows MICAP results for the FY04 and FY05 bases. The average number of MICAPs open reduced 30 percent for FY04 bases and 44 percent for the FY05 bases, while the average number of new starts reduced about the same (18 and 20 percent). The right-hand chart shows the MICAP days reduced even more (41-64 percent). These charts demonstrate that even though COLT is designed to minimize customer wait time, it also does a good job at reducing MICAP incidents and duration.



	Current A	Current B	Current C	06 Qtr 1A	06 Qtr 1B	06 Qtr 1C	06 Qtr 2A	06 Qtr 2B	06 Qtr 2C	07 Qtr 1A	07 Qtr 1B	07 Qtr 1C	07 Qtr 2A	07 Qtr 2B	07 Qtr 2C	08 Qtr 1A	08 Qtr 1B	08 Qtr 1C	08 Qtr 2A	08 Qtr 2B	08 Qtr 2C
New COLT bases	5	5	5	1	14	7	9	6	3	16	14	16	17	10	12	6	5	3	13	13	13
Cum COLT bases	5	10	15	16	30	37	46	52	55	71	85	101	118	128	140	146	151	154	167	180	193

Figure 11. Implementation Schedule

Implementation

Now that we have shown COLT is better—in both theory and practice—than the SBSS demand leveling logic, how are we going to implement COLT throughout the Air Force?

Initial Implementation

The initial implementation plan set a starting quarter for each base to coincide with a base being implemented as part of the Combat Air Forces or the Mobility Air Forces Logistics Support Center (LSC). Working with the LSC builds on almost 2 years of experience, reduces the need for extensive training, and spreads implementation out more than 2.5 years. This initial plan was then modified to spread the workload and accommodate MAJCOM wishes.

COLT will be implemented initially at a base only in the first half of each fiscal year. This allows enough time for initial inventory reshaping and should allow the unit cost ratio to return to normal by the end of each fiscal year. This is necessary because COLT is reshaping the inventory. It increases levels for some items but decreases levels for others. An increase in an item's level often requires an immediate requisition, and a decrease generates long-term sales without offsetting requirements. The longer-term *sales* eventually, usually within 6 months, compensate for the *immediate* spike in obligations for other items.

Figure 11 shows the starting quarter and month within a quarter (A, B, or C) for all bases.

Regular Runs

COLT will be run centrally once a quarter for each base. Think of it as a releveling of all items quarterly. In order to spread the workload on DLA, MAJCOMS, LSC, and the COLT team, one-third of the bases are run each month of the quarter. To facilitate planning, a base's leveling will occur in the same month of every quarter.

The cycle starts in the middle of a month when the central COLT team pulls the data from the centralized database, runs it through the model, and produces the levels and reviews output. The MAJCOMs review this output, and the levels are loaded within the first 2 weeks of the next month.

COLT Levels

When COLT was first implemented, it used fixed adjusted stock levels (ASL) to ensure the COLT level overrides the demand level. Although using fixed ASLs worked, it took more effort to load and did not allow COLT to consider items with minimum ASLs. In early 2006, COLT switched to readiness-based leveling-type levels. This allows COLT to push levels through the Defense Automated Addressing System (DAAS) and include items with minimum ASLs. Note that COLT levels will not be pushed via DAAS for the initial run of COLT at a base and will only be pushed via DAAS after the base, the LSC, and the MAJCOM agree to use DAAS.

Summary

COLT, in theory, is superior to the SBSS demand level and has shown, in practice, to provide better results. COLT is coming to your base. If your base does not currently have COLT levels, it will soon.

Notes

1. Consumable items have a supply code of XB3 and COLT also levels NF1 items.
2. SBSS also caps EOQ at one year. COLT uses the SBSS EOQ.
3. Recall COLT optimizes on Unit CWT.

David A. Fulk, Douglas J. Blazer, and Bernard N. Smith, Jr all work for LMI, a government consulting firm under contract to support COLT development and implementation. Deborah Hileman is a government civilian and is the chief of the analytic application function in the Management Sciences Division at Headquarters Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio.

Jerome G. Peppers—educator, logistician, historian, for whom one of the most prestigious awards given at the Air Force Institute of Technology is named—observed,

> Military history has long ignored logistics. No one wrote about and no one remembers the original logistician. He was probably a mean but smart Neanderthal (or earlier) warrior who spent some time thinking about conditions and began to stock stones, arrows, and spears in logical places for a coming battle. Chances are very good that he won the battle, but we will never know since history doesn't tell us. Many people study the strategy and tactics of great battles, but few study, and even fewer learn of, the logistics actions that contributed so greatly to the outcome of those battles.
>
> Lieutenant General Brehon Somervell in 1944 said, 'History has little to say of the great logisticians, for the prancing charger is longer remembered than the pack mule.' How true. Because logistics lacks *sex appeal,* it finds little coverage in military history or education. It certainly never approaches the dramatic and flowery coverage accorded strategy or tactics. And the published biography of the logistician is extremely rare.
>
> We must recognize that, for logisticians, the study of military logistics history is vitally important because of the nature of the problems faced by military leadership. The study of military logistics history will help the logistician and the student of logistics to more readily identify current problems, and it will suggest potential avenues of solution for those problems. Further and perhaps far more important, the study will help logisticians create more effective logistics systems for tomorrow.

logistics history

Historical Vignettes: Thinking About Strategy and Resources

This edition's Logistics History section features four vignettes written by Robin Higham: "Demand Versus Resources—a Short Historical Perspective," "Logistic Limitations and Grand Strategy—the Dilemma for Underdogs," "Royal Air Force Spares Forecasting in World War II," and "Pipeline Purdah and the Barbed-Wire Strand." Doctor Higham, Professor Emeritus of History at Kansas State University, has educated two generations of historians and is widely known among historians and logisticians alike.

In each of these vignettes presented, the reader will find some very interesting nuggets of truth. For example:

- The wave cycle of aeronautical history shows, on a financial basis, how wars are anticipated in peace. Demands cannot be matched to resources until an all-encompassing national grand strategy for peace and war has been put in place.
- While major powers such as Britain, France, Germany, Russia, Japan, and the United States have at their peaks had enough resources, including manpower, and indigenous manufacturing capacity, the same has not been and is not true for lesser powers. Thus the demand versus resources dilemma has and is much more important and compels the adoption of a viable national grand strategy.
- During World War II, The Royal Air Force found itself saddled with six problems which could not be solved overnight: a lack of standardization; a lack of experience in spares ordering for wartime; a lack of planning for the repair of aircraft; a deficiency in the knowledge of modern production and a lack of understanding of the technological revolution; low serviceability rates; and a shortage of fitters and riggers. It took the first 4 years of war to hammer out the balances and compromises necessary to run a fighting air force and make airpower effective.
- Wartime equilibrium refers to that short period at the peak between rearmamental instability and demobilizational instability when the war economy has been fully developed and crisis has been accepted as the norm. The other equilibrium is peacetime when money rather than time dominates.

Thinking About Strategy and Resources

Historical Vignettes

Demand Versus Resources—a Short Historical Perspective

History provides a vicarious education in examples not personally experienced. Since history repeats for those who do not read it and heed its lessons, it is essential that leaders, managers, policymakers, and budget drafters understand this.

Official historical sections around the world spend a part of each year shooting down ideas their chiefs have proposed because these have been tried in the past. Sometimes they have succeeded, often they have failed, while on other occasions new technology has enabled old concepts to reach reality.

Basic to the way in which ideas and inventions in peace and war are handled is the constant human factor.

As an example, the current concern over demand versus resources follows a precedent set in the Royal Air Force's 1936 *Secret Document 98* (SD98) *Calculations of Wastage and Consumption in War*. The instructions and tables had been worked out in the early 1930s, based in part on World War I experience, and were designed to enable commanders to anticipate their needs, including casualties to men and machines and the supplies of fuel and ammunition required. Air Chief Marshal Hugh Dowding of Fighter Command used *SD98* to prepare for the Battle of Britain.

SD98, however, overlooked wastage of personnel due to fatigue, especially in very intensive operations, which were not, by the way, expected to last more than a very few short weeks.

Dowding won the Battle of Britain for a number of reasons. An important one was that he refused to accept the French demand for most of Fighter Command, arguing correctly that the Air Council had ruled that he needed a minimum of 29 squadrons. Luckily, the Prime Minister reluctantly accepted Dowding's stand and Britain was saved later in the summer of 1940, by which time Dowding had increased his resources to 55 squadrons of 18 rather than 14 aircraft each and 24 rather than 18 pilots. In other words, he matched his resources to demand with the help of both the aircraft industry and of technology (notably the combination of radar with sector control worked out in the air exercises of the later 1930s and grafted onto the basic 1918 concept).

The wave cycle of aeronautical history (Figure 1) shows, on a financial basis, how wars are anticipated in peace. Demands cannot be matched to resources until an all-encompassing national grand strategy for peace and war has been put in place. To make it effective for the armed forces, roles and doctrine have to be agreed to and the consequent requirements in fiscal, industrial, manpower, and infrastructure have to be set in place.

In the examples which follow, the French were defeated in 1940 in spite of having won in 1918 because of memories of trench warfare, domestic democratic disturbances, to use a current phrase, and the national character impeded progress. The Egyptian Air Force suffered defeats at the hands of the Israelis in 1956 and 1967. Egypt's dictator,

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Vignette Acronyms

RAF - Royal Air Force
EAF - Egyptian Air Force
PAF - Pakistani Air Force
SD - Secret Document

One of the lessons from the Battle of France in 1940 was that German officers and even noncommissioned officers had been encouraged to use their own initiative, whereas the British and French high command could not think at blitz speed, while the latter's command system was so rigid that information forwarded up the phone system and the delayed, calculated response was hopelessly out of synch.

General Nasser, recognized the necessity to achieve, if not victory, at least a standoff, by combing the national resources for suitable manpower and concentrating resources on the air and armored forces to meet the demands of another Israeli thrust. Terrain, climate, and a perpetual threat made the Middle East a natural arena of war. But Egypt's resources of all sorts were limited while its own vulnerable targets were concentrated.

Pakistan, like Egypt a Muslim country, faced a more complex grand-strategic situation in an entirely different environment. In a political sense, Pakistan was India's Israel and so was targeted as an upstart after partition in 1947. Like Egypt, Pakistan had to rely upon outside suppliers both for aircraft and spares. Like Egypt, this made it vulnerable to embargoes and compelled Pakistani planners, like Israel's, to use air power as a first-strike rapier in conjunction with a blocking army advance.

In each of these cases, the opponent-enemy had its own plans. After their defeat in 1918, the Germans secretly developed in Russia what became the Luftwaffe doctrine and tactics together with a skeleton air staff in Germany. The new German air force did not intend to be *the air menace* the French and British feared and to which they reacted.

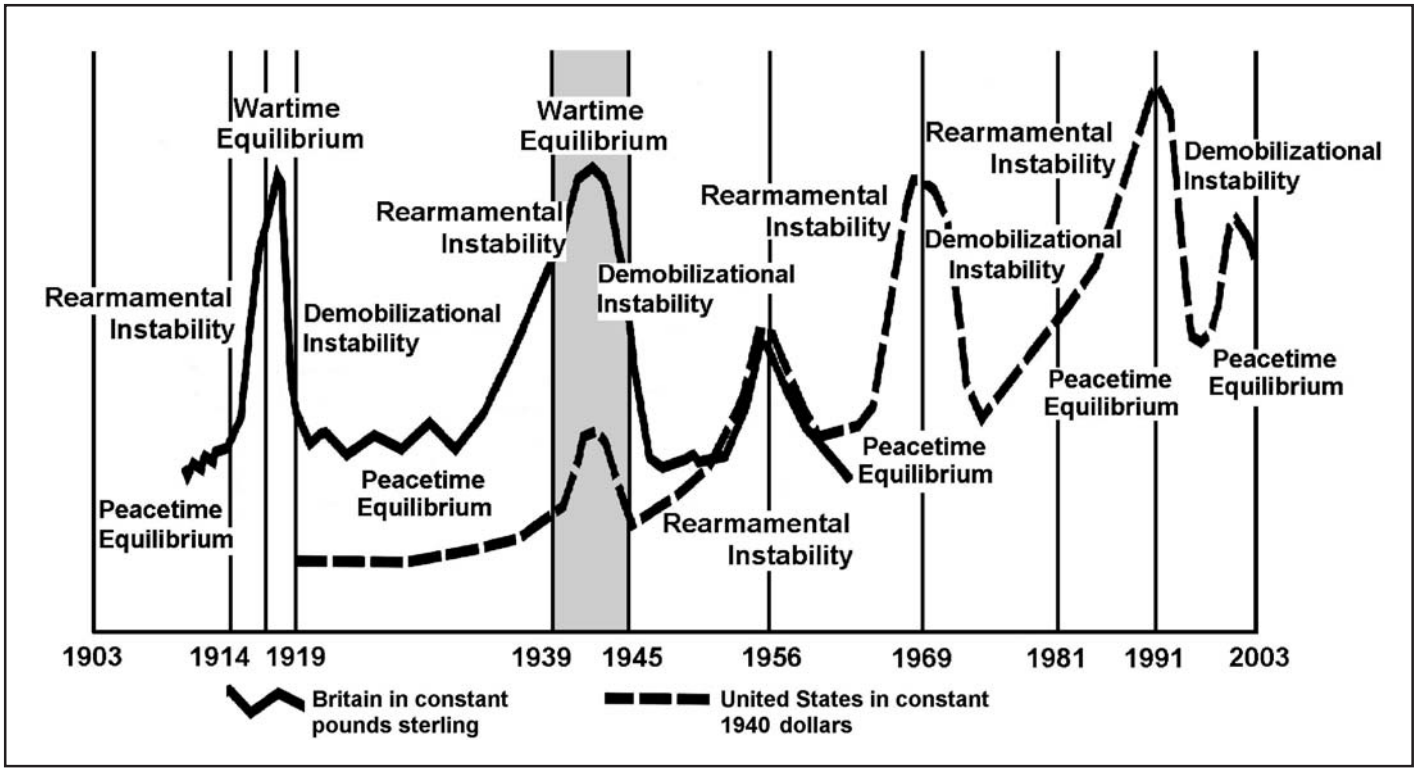

Figure 1. The Wave Cycle in the 20th Century

The Egyptian Air Force had to retrain after the disaster of 1967 from Soviet air defense, ideas based upon countering high-flying US Air Force B-52s, to a counter to the Israeli tactical low-level approach.

The Pakistan Air Force realized the Indian Air Force would, because of like equipment, operate in a manner similar to its own and so developed a first-strike approach to cripple them.

The *Armée de l'Air*, only created in 1933 as an independent arm, was mentally mired in a battle with its late Army parent that crippled the creation of doctrine. At the same time it faced three tasks—defense of the territories, grand-strategic attacks on enemy resources, and army cooperation (assault). This situation meant that there were four very different demands upon French resources—political, fiscal, industrial, and human.

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Money was not available because the Army dominated the defense structure and did not understand the complexities of aviation, while at the same time insistently demanding its own support aviation.

Thus owing to prewar decisions and conditions, the *Armée de l'Air* was short of credits until 1938, short of modern aircraft, and short of aircrew and mechanics.

Modern aircraft could not be produced for a variety of reasons, amongst others, lack of designs, shortage of reliable high-horsepower engines, time in which to test and develop both designs and engines during the technological revolution, properly scheduled delivery of essentials such as propellers and guns, and a paucity of personnel to test and deliver as well as to modify and maintain this equipment. When the *blitzkrieg* hit France, both the 40 percent shortage of mechanics and the absence of a trained reserve of pilots and other aircrew, meant a quick onset of fatigue so that efficiency dropped rapidly. Equally debilitating was the fact that French fighters were slower, heavier, less reliable, and not as easily replaceable as the Luftwaffe's Me-109 and Me-110. In short, the calamity of 1940 had many causes.

In sharp contrast has been the experience of the Egyptian and Pakistan air forces because they have not only survived wars, they have also had a determined higher direction.

In 1956, and more so in 1967, Israel showed that modern limited wars had to be short. Indeed, their similarity to the campaign of 1940 emphasized the same dilemma of demand versus resources. The high rates of wastage and consumption in intensive operations very quickly drained reserves. This was well demonstrated in the 1973 Arab-Israeli Ramadan (the Yom Kippur) War when both of the then superpowers, the Soviet Union and the United States, had to reprovision their clients.

In Egypt, General Nasser started after the Suez War of 1956 to reconstruct and reconfigure the Egyptian Air Force (EAF) with the help of massive Soviet resources. At the same time, he had to recognize the nature of his own population—half urban and concentrated on only four percent of the land, prone to await plans and orders from above, and generally lacking education and industrial skills. Nasser, therefore, concentrated his efforts at recruiting from the elite, educating them as airmen, and making their profession respectable among their peers. However, his Soviet instructors tended to reinforce the Egyptian lack of initiative by their massive welded-wing formations and high-altitude tactics.

After the 1967 defeat, Nasser forced the EAF to practice against low-level attacks, hardened his bases, and engaged in electronic warfare. By 1970, the combination of the EAF with Soviet flak defenses, formalized by Anwar Sadat after Nasser's death in September 1970, brought a stalemate.

In 1972, Sadat expelled the Soviets and allowed Hosni Mubarak to prepare plans for a limited war against Israel. Though the 1973 Ramadan War still led to defeat, both sides realized the futility of further hostilities. In the years that followed, Egypt's demands were satisfied with US resources putting the EAF on a par with the Israelis, which for a while led to a formal peace with Israel.

In the Indian subcontinent, geography and climate are very different. From Partition in 1947 to the independence of East Pakistan in 1971, Pakistan faced a multifront war with India, the Kashmir problem, and a threat from Afghanistan. Like the Egyptian

and Indian air forces, the Pakistani Air Force (PAF) had a British legacy and also lacked an indigenous aircraft industry. However, Pakistan had a fighting tradition and many skilled arms makers, as well as a dictatorship. And also like the Egyptians, Pakistan, and India too, faced an uncertain foreign supply of the sinews of war. Ultimately the fickleness of US foreign policy forced the PAF to develop its own spares industry.

Nevertheless, because of its underdog situation (by 1971 the PAF was only 22 percent the size of the Indian Air Force), Pakistan's grand strategy had to be a devastating first strike against the Indian Air Force.

The PAF has owed its successful survival to focused leadership, constant innovation and development, rigorous training, and persistent analysis of exercises and refinement of operations together with a willingness to change quickly. Not only did the PAF create an indigenous spares industry, and adapted foreign aircraft such as the US F-86, the Chinese F-6, and French Mirage-IIIs, but it also created the *Mobile Observer Units* and then withdrew them when they proved vulnerable to guerrillas. By this time the PAF had better radar and electronic defenses in place together with navigation aids to refine the accuracy of strikes.

Faced with heavy demands, the PAF made the most of its resources.

Conclusion

It should be noted that there are interesting parallels with past aeronautical history, as well as some what-ifs.

France failed to deter the Second World War in 1939-1940 because her armed forces were in no position to face down Hitler to make him reevaluate an attack. The *Armée de l'Air* lacked the wherewithal from the will or the political leadership and credits to personnel and competitive serviceable aircraft.

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The Egyptian Air Force has shown that the demands of defense have to be faced by analysis and focus on the appropriate resources while allowing an outsider to make up wastage and consumption.

Both the Egyptian and the Pakistan air forces created determined, flexible commands with fluid communications.

Logistic Limitations and Grand Strategy—the Dilemma for Underdogs

Logistic limitations have always existed given fiscal restraints and political perceptions of danger. Demand versus resources has been a constant tension. While major powers such as Britain, France, Germany, Russia, Japan and the United States have at their peaks had enough resources, including manpower, and indigenous manufacturing capacity, the same has not and is not true for lesser powers. Thus the demand versus resources dilemma has been and still is much more important and compels the adoption of a viable national grand strategy.

Such a policy is one that is not only continuous in peace and war, but also takes into account all necessities for the nation's life and survival.

Thus policymakers and executors have to consider not only the requirements for survival, prosperity, and welfare, but also the allocation and distribution of all resources, recognizing that demands have to be prioritized.

Students of war and of the military tend to forget that peace is the norm and war the exception. At the same time, it is vital to remember that wars were often won by the side whose peacetime policies and practices led to adequate sinews of war.

All of the above applies especially to the powers such as in the post-1945 era Israel, Egypt, and Pakistan. Interestingly, their air forces like most in Africa, India, Singapore, and others are legatees of the British Royal Air Force. Their histories have many worthwhile parallels with those of older air forces such as the French *Armée de'l Air* and the German *Luftwaffe*.

Israel, Egypt, and Pakistan have each been underdogs facing potentially superior enemies. With a *Sword of Damocles* hanging over their heads, they have been forced to concentrate upon realities. Like oriental martial-arts warriors, their best defense has been a focused offense. Moreover, because of the difficulties and uncertainties of resupply, they have been forced to plan to deter their opponents by concentrating on what the German General Staff called the *schwerpunkt*—that the enemy has been willing to make peace, in part because in the case of Egypt it, too, was exhausted. In the case of India, involvement in a long war was politically undesirable.

Both Israel in 1956 and 1967, and Pakistan in 1965 and 1971, saw that their only viable grand strategy was to attempt a lightning knockout blow against their opponent. Since they did not have the resources for a grand-strategic bomber force, enemy targets were limited, their own resources were in fighter-bombers, their pilots and support forces, the preemptive strikes had to be within the low-level range of these jet aircraft. So multiple strikes were planned for just after dawn and just before sunset on the opening day. Such intense activity drained spares pools to keep aircraft serviceable and fatigued ground crew.

One of the first lessons, therefore, was the need to double not only the pilots per aircraft, but also the ground crews on each squadron, as well as personnel on the stations and in the control rooms. The same had been found true of the antiaircraft defenders of England in the Battle of Britain. Logistically, this meant doubled consumption of rations, housing, and so forth.

Such preemptive strikes also required a high stock of readily available fuel, ammunition, bombs, and spares.

In both the Israeli and the Pakistan air forces, it was clearly understood that in wars, hopefully, lasting 6 days or less—the

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near limits of their logistics—that everyone had to be prepared to switch tactics the minute it became evident that current doctrine was ineffective or counter-productive.

Both the Israeli and the Pakistan air forces proved historical points by their opponents' unpreparedness. The Egyptians and the Indians were both early on vulnerable to attacks on their aircraft parked unprotected in the open and on their above-ground fuel dumps. However, these air forces learned to provide hardened shelters and underground fuel supplies. Thus after having been caught flat-footed in 1965, 24-hours after war began with their aircraft still parked wingtip-to-wingtip, by 1971 the Indian Air Force had its machines in hardened shelters, its fuel protected, and its airfields camouflaged and ringed by antiaircraft artillery and fighter patrols, but not low level radar. As a result, as in Egypt in 1967, the attackers used dibbler bombs to crater the runways—targets large enough to be seen and hit by fast-flying, low-level fighter-bombers. The latter became a favorite of lesser air forces—a heritage of Luftwaffe hit-and-run raids in the Battle of Britain and after, because the machines could quickly be switched from attack to self and air defense. This was both a tactical and a fiscal imperative.

For small air forces, the greatest possible flexibility is needed because accidents can have a serious effect. In 1971 two out of the three Pakistan Air Force Mirage III PRU aircraft were grounded on the first day by bird strikes. More recent development of pods has provided a solution to such a devastating loss.

While the aim of the majority of air forces, large or small, is to keep the peace, that of the smaller services, especially those adjacent to hostile neighbors, has been to deter any would-be aggressor. The difficulty rises as the range of aircraft increases so that the advantage of space swings to the physically greater power, the one with the larger area for dispersal of its assets, especially beyond radar range.

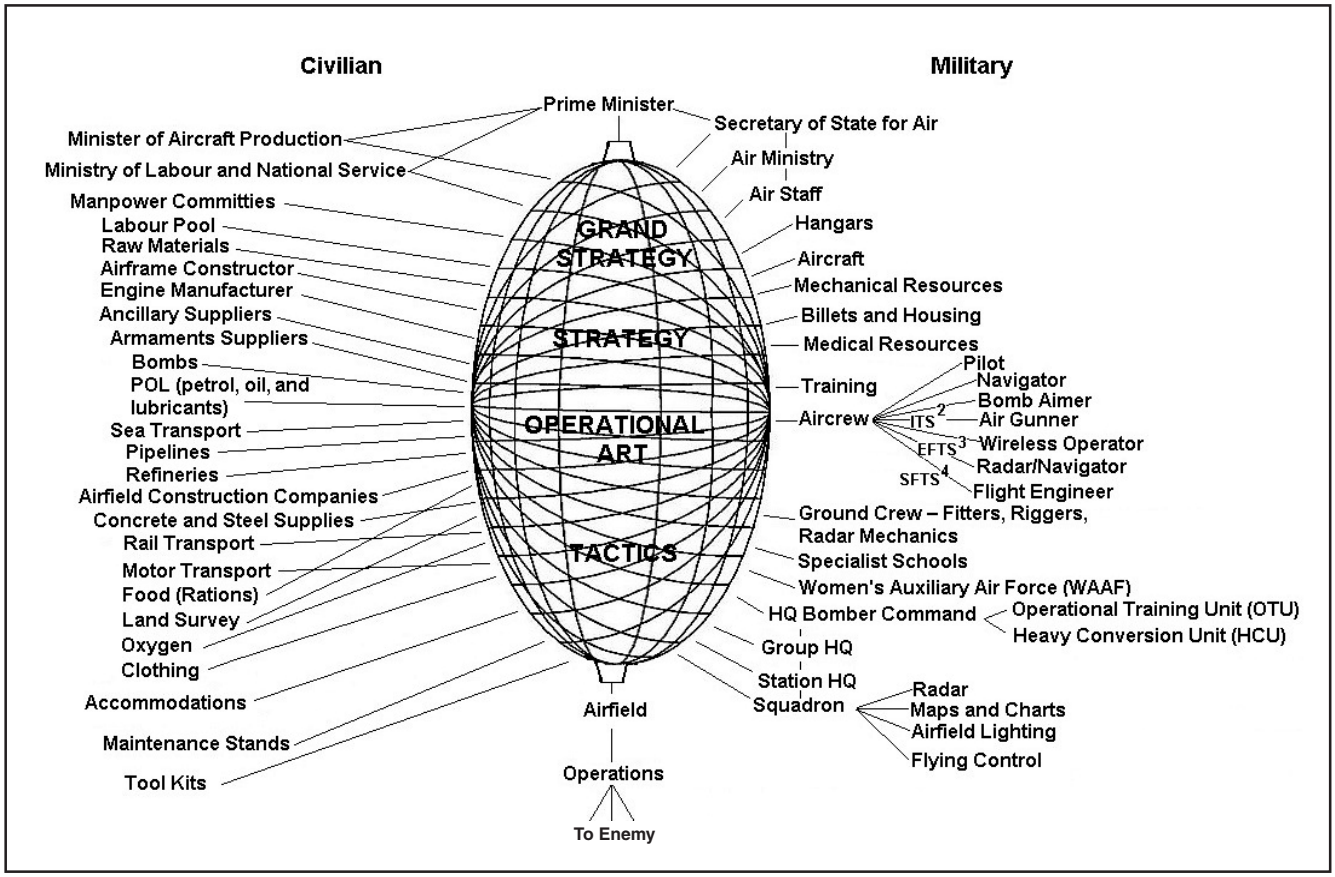

Figure 1. The Invisible Infrastructure—the Bamboo Basket

Under the circumstances, alliances are needed to be able to obtain shared satellite intelligence. It is also a requirement because even Israel is not self-sufficient. It is more so in the cases of Egypt and Pakistan. History has shown the necessity of reliable outside sources whether it is the late Soviet Union, the United States, Britain, France, or China. While, as in 1973, massive airlift is possible for a short vital period to replenish almost exhausted stocks, for other than aircraft refuelable enroute, sealift has to be the solution due to lack of rail connections. This means that a prime logistic requirement is freedom of the seas and accessible ports with either roll-on, roll-off piers or full-service docks. It also means that those ports and their alternates have to be protected, as do their storage and distribution systems. Man- and woman-power has to be deployable and available, with all that involves from unskilled stevedores to technically trained assemblers.

Thus it should become clear that the background to grand strategic decisionmaking as demonstrated by the accompanying diagram for air power in Britain in World War II (Figure 1) is a very multifaceted matter whose timeline stretches back several years before war breaks out. For lesser powers with limited resources this requires, then, national planning and execution of a constant in peace for success in war if that collapses.

Royal Air Force Spares Forecasting in World War II

Early investigations into the spares problems of the Royal Air Force (RAF) in World War II suggest that many hidden human failings delayed the impact of airpower until late into the war.

For example, in September 1939 when war broke out, the RAF had some 59 types of aircraft in the inventory or on order. Even though these aircraft contained standardized items for which tool kits were issued to mechanics, had standard blind-flying instrument panels in the cockpits, and standardized placement of instruments, much was missing and complicated by the revolutions taking place in aviation. New airframes, new engines, and new ancillary equipment were becoming available, but many items were nonstandard because they had not yet been proofed, approved, and ordered in quantity.

A second problem was how to order spares. It was envisaged almost exclusively on a peacetime basis. The trouble was, the spares system was geared to peacetime, where only one or two squadrons of a particular type aircraft were flown very few hours with gentle professional handling. From 1934 onward, however, the RAF was in rearmamental instability. Under a situation of rapid change, it was hard to know how to order spares when there was little experience with a certain aircraft type. Moreover, factories did not wish to produce spares, as they only got credit for complete aircraft.

The rule of thumb was that an aircraft type should be ordered with a 27-month package of spares for peacetime operations plus additional spares for 4 months of war. Due to bureaucratic lag, the spares were not ordered until after the manufacturing program had begun. Attempts were still going on three years after the war started to get factories to allocate ten percent of their floor space to the manufacture of spares or to allow outside subcontractors to do the work. When the initial approach was found incompatible with factory work loads, or as some said, with the fact that the factories simply were not interested in damaging their production record, the Ministry of Aircraft Production decided to cut the requirements to a 15-month peacetime and 4-month wartime stock of spares. But then it was pointed out that less than an 18-month supply would not allow enough experience upon which to base future orders for spares based upon actual consumption of individual items. To that dilemma was added an additional demand for new parts for repairs. In fact, by mid-war some 40 percent of the British operational aircraft available in the United Kingdom were rebuilds.

Part of the problem was that prewar discussions, until just before war broke out, did not cover the matter of repairs, but did contain the idea that within three months of the outbreak of war, factories would be running at full wartime capacity. Part of the reason for this naiveté came from a failure to study World War I. Though it was true staff work had begun as early as 1924 on a document which finally saw the light of day in 1933 as *Secret Document 78, Tables For Estimating Consumption and Wastage in War*, and in 1934 as *Secret Document 98*, also entitled *Tables For Estimating Consumption and Wastage in War*. These were not firmed up until 1936, and were then substantially gutted and reworked by 1941. However useful these tables were, they failed to deal with salvage and repair, or with the lessons of 1918, when there were very high casualties from operations, not all of which were lost over enemy lines.

Another difficulty was that the High Command was not only deficient in its knowledge of modern production and the time needed to assemble raw materials and trained manpower for that activity, but it was also wanting in an understanding of what the technological and other revolutions were all about. Not only did aircraft, for instance, require far more parts and a greater knowledge of how to assemble and repair them, but also complexity had a multiplier that affected all operations as well as manufacturing.

Few people understood what a modern industrial war would require five years before war broke out, in addition to four years after it was declared, before wartime equilibrium would be reached. The latter was a short stage when everything was up and running not only militarily, but also bureaucratically, industrially, and the like.

During the Battle of Britain in 1940, the Inspector General of the RAF toured the available airfields. He found that the lowest serviceability rates were at Training Command stations where only 59 percent of the allocated 150 Spitfires and Hurricanes were serviceable. Why was the rate so low at a time of crisis? Basically, because either the fitters and riggers did not have tool kits or spares were not available, or both. At Fighter Command the

serviceability rate was 75 percent. At Bomber Command the rate was 82 percent except in the No. 2 Group where the Blenheims and Hudsons were at 106 percent. This was because the aircraft were not being used in the Battle of Britain and the ground crews had time to bring even the spare aircraft up to available status.[1]

Availability also had to do with the system of recording aircraft states (status). At 1700 hours daily the equipment officer had to call into headquarters the squadron's state:

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- Aircraft currently available at dispersal.
- Aircraft which would be available by 0900 the next morning.
- Aircraft which would become available in 24 hours.
- Aircraft which could be repaired at the station in 34 days.
- Aircraft write-offs, meaning essentially that their repair was beyond local capability.

The aircraft write-offs were replaced from the local storage unit, but they dropped off the paper record. This explains why the graphs for aircraft in Fighter Command during the Battle of Britain show a steady decline of machines in the storage units, even though Spitfire and Hurricane production and losses were about equal.

Another way of looking at the matter of repairs was a study done by the Ministry of Aircraft Production. This study looked back on the war in terms of repaired aircraft as a percentage of total production. In May 1940, the figure stood at 13.5 percent of 1,298. By September it had risen to 37.6 percent of 1,906. In November 1940, of the 42.1 percent of repaired aircraft out of a total of 1,927 aircraft added to stocks, 300 were being repaired *in situ* (where they lay) and 512 were at works (returned to factories) for a total of 812, or more than all aircraft production in September 1939. By late 1942, the number of repaired aircraft available that month was the highest of the war, 53.9 percent of 3,179, or 1,714. The highest total number ever returned in one month was in June 1944, when 1,903 aircraft were added to production totals.[2]

What had made this possible was that, in addition to *in situ* teams, the RAF had managed to get its own repair and maintenance facilities. These facilities were originally envisaged as six (three civilian and three RAF), one million square-foot depots, with 10,000 men each.

Of course, the demands from expansion of the RAF put the RAF into competition with all the other technical services and industries for manpower. For the RAF, this was complicated by the prewar insistence that it took 7.5 years to train a fitter or rigger fully. Even when the frontline strength was pegged briefly at 750 aircraft, the RAF needed an intake of 1,000 fitters and riggers a year through Halton, the apprentice training establishment, but was only getting 200.

Summary

The RAF found itself saddled with six problems which could not be solved overnight:

- A lack of standardization
- A lack of experience in spares ordering for wartime
- A lack of planning for the repair of aircraft
- A deficiency in the knowledge of modern production and a lack of understanding of the technological revolution.
- Low serviceability rates
- A shortage of fitters and riggers

It took the first four years of war to hammer out the balances and compromises necessary to run a fighting air force and make airpower effective.

Notes

1. *Air Superiority*, Office of Air Force History, Washington DC: AFHSO/HO, 1995.
2. AVIA 46/228, Ministry of Air Production, *Aircraft–The Spares Problem–Narrative*, London.

Pipeline Purdah and the Barbed-Wire Strand

In Moslem countries purdah is seclusion from the public of female *assets*. *Pipeline purdah* is when assets such as new aircraft and spares or personnel are unavailable because they are in-transit.

For the British in the Second World War, this became a critical condition with the fall of France in June 1940. Until the Italians entered the war in that month and the Middle East became a theater of war, transit delays were only a matter of days between Britain and forces in France. But once the Italians closed the Mediterranean, the 6000 miles from the United Kingdom or the US to Egypt became a 3 to 6 month matter.

This was especially critical in the early years of the war before production and purchase of provisions had reached such wartime equilibrium levels that the pipeline was full and supplies flowed out the far end at about the same speed as they were pumped in.

Wartime equilibrium refers to that short period at the peak between rearmamental instability and demobilizational instability when the war economy has been fully developed and crisis has been accepted as the norm. The other equilibrium is peacetime when money rather than time dominates.

In the case here, pipeline purdah was critical since the Middle East had not been envisioned in prewar days as a theater of war. Thus, it was essentially garrisoned to a peacetime colonial level and was short of everything from men and supplies to the invisible infrastructure of air stores parks, workshops and airfields, not to mention repair and salvage facilities, fuel storage, etc.

Thus, at the time the Royal Air Force (RAF) was dispatched to Greece in November 1940, there was a critical shortage of aircraft. This became a highly acrimonious matter between headquarters in Cairo and the Cabinet in London, resulting in the end in the recall of the long-suffering Air Officer Commanding-in-Charge, Middle East. It was only at that critical juncture when Greece and Crete had fallen in April and May 1941 that someone in London saw fit to comment that, of the 1782 aircraft which had by that time been allotted to the Middle East, only 330 had actually arrived. This observer failed to note that even those in the theater, such as the 28 Wellington's of Nos. 37 and 38 Squadrons, had only flown 12 operational sorties in support of operations in Greece in 6 months in the Middle East. Moreover, all the Hurricanes dispatched across the desert route to Cairo from West Africa via Khartoum had to be stripped and inspected before they could be issued to operational squadrons. Without the necessary invisible infrastructure that existed in Britain, this was a time consuming process not really eliminated until after the establishment of a full-scale base in Egypt. Meanwhile, operations, as well as ferrying, caused wastage to exceed replacements, thus making the Royal Air Force Middle East at times almost impotent.

The Barbed-Wire Strand

Moreover, pipeline purdah was and is related to the barbed-wire strand. In this conception, all of the information, decisional analysis and the decisions themselves can be viewed as points along a strand of barbed wire; the segments between the barbs as periods of time; and the barbs themselves as events (both good and bad). Continuing with this conception, in the time between facts becoming evidence, management or command becoming aware of them and making a decision, the facts may have all changed. This is why it is critical that command be able to think and see the strand between the two ends and not just between two barbs, or only a single barb.

In the Middle East case it was also critical that London recognize that the Germans had interior lines and could switch assets from France to Sicily and the Balkans much faster than the British could. So for the British in Greece and the Middle East there was a need to equip the RAF with first-line machines and not with those cast off or not wanted at home. In other words, it would take prescience of mind to see that what mattered took account of both pipeline purdah and of the barbed-wire strand effects.

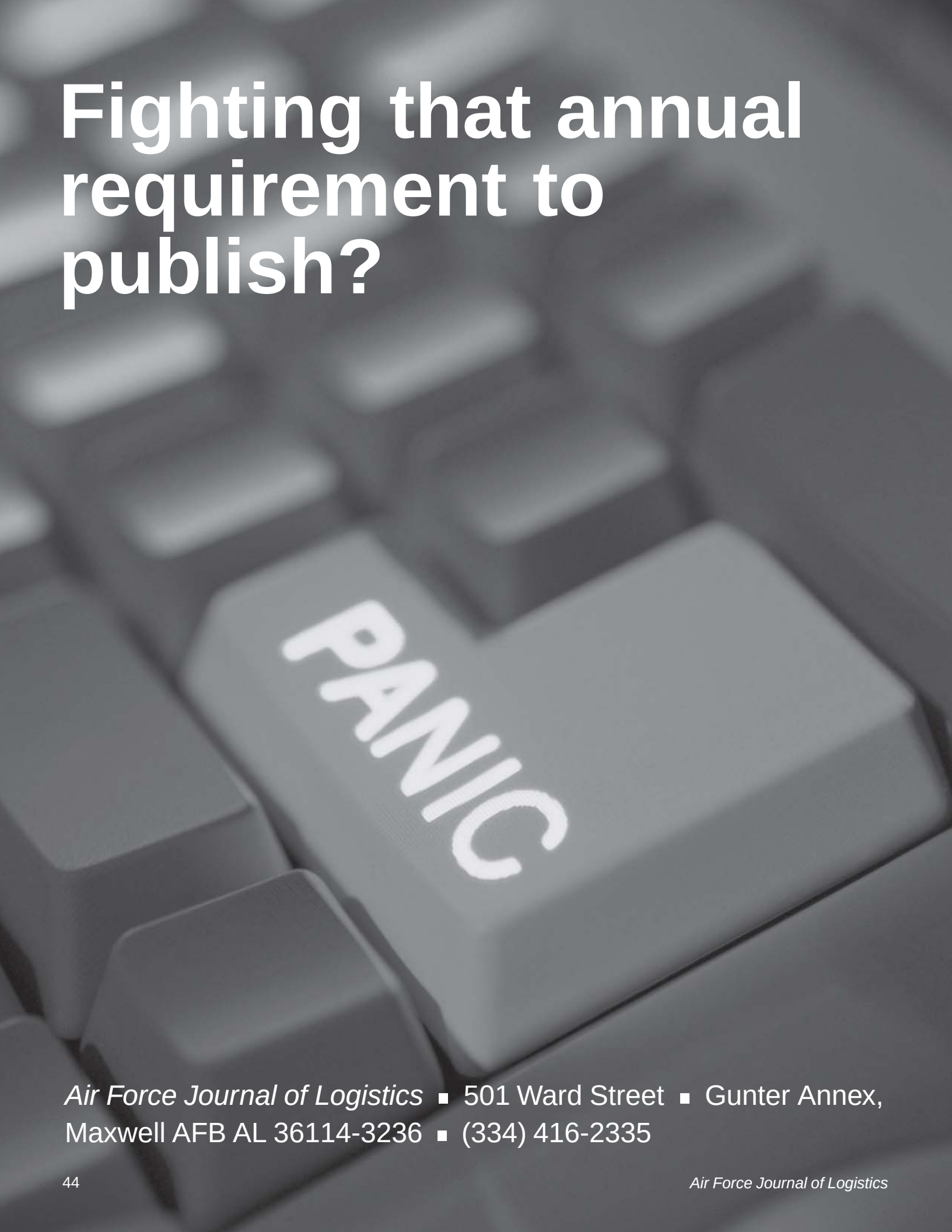
Robin Higham, Professor Emeritus of History at Kansas State University, is a frequent contributor to the Air Force Journal of Logistics.

notable quotes

Before World War II the Royal Air Force had in SD98 of 1936, developed tables for the wastage and consumption of an air force at war. If SD98 had been remembered, it would have provided very useful guidance. Just because a document is historic, the ideas and methods it contains should not be ignored. Otherwise planners and fighters are doomed to repeat the reinvention of the wheel!

—Robin Higham

Fighting that annual requirement to publish?



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General Kenny on Far East Supply Concepts

When we went into the Philippines, it was at a time when Europe seemed to be needing more shipping than it had ever needed before and that minor war over there was surely absorbing a lot of everything. So they cut down the number of boats that we had, and we were really in tough straits. When we first went into New Guinea, we had this bright idea that you couldn't do anything unless you had a 120-day stockage of everything. We cut that down to 90, with some misgiving on the part of MacArthur's supply crowd, and then I cut it to 60 and even to 30, and even the Air Force began to howl about 30 until they saw that Air Transport could pick up the slack.

When we started into the Philippines, the shortage of shipping was so acute that we landed on the island of Leyte with 5 days' stockage, and we never got more than 5-day stockage. We didn't want more than that because, by this time, we had air supply. We were flying gasoline, we were flying bombs, we were flying food, we were flying stuff for the infantry as well as ourselves. We were really doing a job with air transport. Where in the original part of the game we had to build warehouses and set up a depot and build terrific warehouses to stock stuff in and the stuff would get spoiled, and the bad weather and everything, now we didn't have any stockage in there at all to amount to anything. These depots were largely depots repairing wrecks, and if we needed a spare part, we would fly the thing in. We would fly engines in. We were overhauling engines in Australia, and as the thing got off the test stand, it went right into an airplane. And inside of 5 or 6 hours, they were putting it in a bomber up in New Guinea.

Suppose, on the other hand, you do it the old-fashioned way. You take the silly engine off here and disassemble half of it and wrap it up in little packages, and they get lost when they open the crate. Everything is supposed to be proofed against this damp tropical weather and proofed against the salt spray that they get, because they always put out stuff on the decks.

These big heavy crates are made so you can drop them from the crane to the bottom of the hold, in case they did put them in the hold, and not break anything. Everything is filled up full of cosmoline, and then they load these boats until they have enough for a convoy. A month goes by. This thing has gotten all rusted, and the pistons won't move, and the crankshaft has red spots on it. When you do get the cosmoline off it, you haven't an engine until 2 months have gone by.

There was no doubt, as soon as we started in doing this stuff, that was the way to run a fast-moving war, especially when you were on a shoestring. And we finally found out that the way to run a war was on a shoestring anyhow, that was modern war, faster, and the whole Pacific campaign that MacArthur had would still be going on trying to get out of Port Moresby if it hadn't been for the transport.

General George C. Kenney, Speech for Air Force Association, 1952

EXPLORING THE HEART OF LOGISTICS

Improving Equipment Management Using Lessons Learned from the Air Force Spares Management Process

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Introduction

For the last two years, and under the direction of the Warner Robins Equipment Management Office (542d MSUG/GBMM), the Air Force has improved its equipment management process, developing automated tools that have improved the equipment requirement methods and execution of logistics decisions, such as buy, repair, distribute, redistribute and allocate funds. The underlying reason was to apply successful spares management technology and business practices to equipment.

In the late 1980s, the Air Force developed a way to link mission capability, that is, aircraft availability, to spares funding. The Air Force could identify the change in the number of available aircraft that would result from a change in spares funding, and aircraft availability became the prioritization logic for spares execution decisions. The spares community also employed automated systems like the Execution and Prioritization of Repair Support System (EXPRESS), to prioritize the repair, distribution, and redistribution of assets that exceeded a base's requisition objective.

Article Acronyms

AFEMS - Air Force Equipment Management System
BP - Budget Program
ERS - Equipment Requirements System
EXPRESS - Execution and Prioritization of Repair Support System
FAD - Force Activity Designator
FY - Fiscal Year
MAJCOM - Major Command
O&M - Operations and Maintenance
SET - Support Equipment Transformation
SORTS - Status of Operational Readiness and Training System
UMMIPS - Uniform Material Movement and Issue Priority System

Current equipment systems do an adequate job of computing the spares requirement, but nothing ensures the effective fulfillment of that requirement. The equipment community cannot link mission needs to equipment requirements, nor does it have the automated tools to make equipment execution decisions. There is no systemic redistribution of malpositioned equipment. In addition there is no way to prioritize repairs or identify repair backlogs.

Until recently, no equipment system could ensure serviceable assets were released promptly. Further, there was no way to prioritize what to buy or how to allocate funds to maximize Air Force mission capability. These execution decisions depended on item managers continuously reviewing their inventories. There were no tools available to let those managers know that action was required. More importantly, no tools considered the entire Air Force enterprise in execution decisions.

When funds are limited, what is the next item that should be inducted into repair? Nothing provided the necessary oversight and enterprise prioritization to ensure the right decisions were made.

In the last two years, the Air Force has found a way to link equipment support to Air Force readiness. This association is the key to determining the most effective way to execute equipment decisions that result in the largest number of organizations reporting as mission ready. Aside from supporting funding decisions, the linkage provides a basis from which to prioritize equipment requirements and decide how best to spend limited resources.

Using the prioritization logic of the Status of Operational Readiness and Training System (SORTS), LMI developed automated processes to perform the following.

- Prioritize equipment buys
- Distribute equipment

- Redistribute improperly positioned equipment
- Induct items into repair

LMI also developed an automated process that will improve the accuracy of the Air Force's forecasting and computation of replacement needs.

Equipment Prioritization

The Air Force now uses prioritization logic to link readiness to support equipment purchases. The prioritization logic uses SORTS-driven fill rate targets to make asset and resource allocation decisions (see Table 1). This approach uses marginal analysis to maximize the number of organizations that are fully mission ready by force activity designator (FAD) and use code (A for mobility, D for war readiness materiel, and B for support equipment).

Figure 1 illustrates how the prioritization logic ranks equipment. In a waterfall effect, it allocates assets to FAD I, II, and III, use code A units until those organizations achieve a 90 percent (S-1) fill rate. It then allocates assets to FAD IV and V, use code A organizations until they reach an 80 percent (S-2) fill rate, and so on.

Table 2 presents the fill-rate targets for each prioritization tier. Once all organizations meet their Tier 1 fill-rate target, the prioritization process starts over for the next tier, with higher fill rate targets.

LMI applied this prioritization logic to the fiscal year (FY04) support equipment buy list by organization for each stock record account number, and compared the resulting Air Force's SORTS-driven fill rates to the current Uniform Material Movement and Issue Priority System (UMMIPS) method of prioritizing requirements. Table 3 presents those results.

The Air Force funding in FY04 for budget program (BP) 12, common support equipment, was $217M. Applying the SORTS-driven fill-rate targets, the Air Force would have prioritized the purchase of 18,000 units of equipment. This is a marked increase from the 7,400 units of equipment the Air Force would have purchased with UMMIPS. The SORTS-driven prioritization approach would have also resulted in 2,943 S-1 rated organizations, whereas only 1,339 organizations would have been S-1 rated had the UMMIPS method been employed.

In other words, the use of the new prioritization logic would have resulted in a 120 percent increase ([2,943 - 1,339] ÷ 1339 = 1.2) in S-1 rated organizations for BP-12 purchases, and a 68 percent increase ([3,858 - 2,289] ÷ 2,289 = 0.68) in S-1 rated organizations for BP-84 purchases. Likewise, there would have

SORTS Code	Fill Requirement	Fill Target
S-1	Fully wartime mission ready	> 90%
S-2	Capable of most wartime missions	> 80%
S-3	Capable of many portions of its wartime missions	> 65%
S-4	Not mission ready without more resources	< 65%

Table 1. SORTS Ratings

Category	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6	Tier 7	Tier 8
Spares Priority Release Sequence									
All Use codes—100%									
Use code A (Mobility)									
FAD I, II, and III	–	90%	90%	90%	92%	94%	96%	98%	100%
FAD IV and V	–	80%	90%	90%	92%	94%	96%	98%	100%
Use Code C (Joint Use) and Use Code D (WRM)									
FAD I, II, and III	–	90%	90%	90%	92%	94%	96%	98%	100%
FAD IV and V	–	80%	90%	90%	92%	94%	96%	98%	100%
Use Code B (Support Equipment)									
FAD I, II, and III	–	80%	90%	90%	92%	94%	96%	98%	100%
FAD IV and V	–	65%	90%	90%	92%	94%	96%	98%	100%

Table 2. Prioritization Tiers

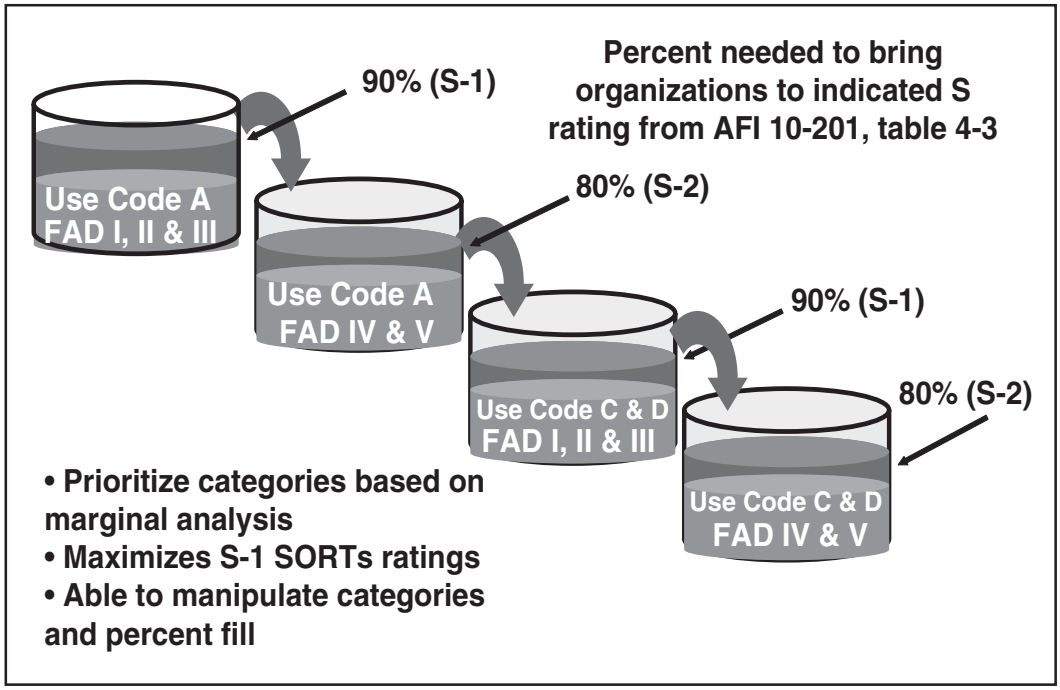

Figure 1. Prioritization Execution Waterfall

BP-12 ($217M)	Number of Units Purchased	Number of Organizations 90% Fill	Number of Organizations 80% Fill	Number of Organizations 65% Fill	Number of Organizations < 65% Fill
Start	–	694	734	837	1,000
Current System—UMMIPS	7,400	1,339	538	618	770
Proposed Marginal Analysis	18,000	2,943	109	213	0
BP-84 ($242.5M)	**Units purchased**	**Number of Organizations 90% Fill**	**Number of Organizations 80% Fill**	**Number of Organizations 65% Fill**	**Number of Organizations < 65% Fill**
Start	–	924	346	855	2310
Current System—UMMIPS	34,300	2,289	181	494	1,471
Proposed Marginal Analysis	42,200	3,858	486	91	0

Table 3. FY04 Funding Results

been no S-4 rated organizations, compared to 770 [BP12] and 1,471 [BP-84] with UMMIPS, for other base maintenance (BP-84) and support equipment (BP-12).

The Air Force implemented LMI's prioritization logic into the Equipment Requirements System (ERS), and that logic was used as the basis for the FY06 buy requirement provided to the major commands (MAJCOMs) for their review and adjustment.

Buy Execution

The Air Force needed a way to determine what to buy with limited funding. Historically, equipment receives 40 to 60 percent funding, without any way to systemically determine what purchases will maximize mission effectiveness. Under the support equipment transformation (SET) effort, the Air Force needed a way to prioritize and identify the items it wanted to fund and have the equipment item managers buy.

The Air Force ERS uses the prioritization logic and links the user's requisitions to the computed requirement to provide a suggested buy list for the MAJCOM review. The MAJCOMs can modify the priority list and apply their operations and maintenance (O&M) funding. ERS then consolidates the MAJCOM lists for Air Force Materiel Command buy execution. For items that cost more than $250,000, ERS also prioritizes centralized support (that is, non-O&M funded) equipment for MAJCOM review.

Organization	Use Code	FAD	Target Fill Rate	Fill Rate	Marginal Gain	Priority
123	B	3	80%	85%	7%	3
789	A	2	90%	88%	5%	1
456	A	2	90%	86%	2%	2

Table 4. Sample Asset Distribution Prioritization

Total Unserviceable		Unserviceable Aligned in Computation		Not on Work Order		Back Order	
Units	Repair Cost	Units	Repair Cost	Units	Repair Cost	Units	Repair Cost
126,000	$465M	112,000	$49M	8,200	$44M	4,100	$25M

Table 5. October 2005 Equipment Repair Position

More work is needed in ERS to better reconcile the MAJCOM requisitions to the computed requirement and to track MAJCOM funds. To do so, the Air Force developed use cases for ERS as a way to track how the air logistics centers purchase the items that the MAJCOM funds.

Asset Distribution

Before SET, the Air Force needed a way to determine where to distribute an asset when it became available. LMI developed an automated program that incorporates the marginal analysis prioritization logic to suggest where to distribute available assets. This asset distribution list is based on the individual fill rate of each organization. It prioritizes the asset's release to ensure the greatest improvement in fill rate as targeted by the use code and FAD. The resulting list is developed every 2 weeks and posted on a Web site.

Many SET items are available for distribution because they are purchased. These items should be released to the MAJCOM, and specific requisition, that funded the buy. For assets that are available because of nonpurchase actions, the item manager can use the new distribution list to release the asset to the organization with the greatest need.

As an example, Table 4 lists three organizations that require an available asset. The first asset goes to organization 789, because that organization is below its targeted fill rate and has the highest marginal fill-rate gain (5 percent). Although organization 123 has a higher marginal gain (7 percent), it already exceeded its target fill rate.

The capability to provide an asset distribution priority list should eventually be part of the ERS. The ERS asset distribution should include MAJCOM prioritization and track funding to identify what requisitions have been funded and by whom, thus ensuring the MAJCOM that funded the buy or repair, receives the item it needs.

Redistribution

The Air Force did not systemically redistribute malpositioned equipment that is either in a warehouse or identified by a special allowance standard (for example, 000, nonauthorized; 048, temporary loan; and H000-WRM, no longer authorized) as no longer needed by the organization in possession of the equipment.

The Air Force equipment computation system (D200C) applies malpositioned equipment to fill a valid need. If the asset is not redistributed to fill that need, the need will go unfilled indefinitely. The computation will not allow a buy when there is an asset available to meet the need. Because the Air Force does not redistribute its malpositioned equipment, needs go unfulfilled.

Malpositioned assets can also be the result of *dirty* data. Some assets listed as *in warehouse* or *000, nonauthorized,* do not exist, or are no longer *000*. Failure to either redistribute the equipment or clean up the data means users' needs are never satisfied.

In coordination with the Air Force Logistics Management Agency, LMI developed a semiannual process to identify and create transactions to redistribute malpositioned equipment. We again used the marginal analysis prioritization logic to determine which of the competing requirements to fill with the malpositioned assets. The program creates turn-in and shipment transactions that the bases and regional supply squadrons process. The LMI program includes equipment in a base or depot warehouse and in-use with allowance source codes of 000, 048, and H000. The program also identifies—for MAJCOM review and action—equipment with other allowance source codes the computation applies to valid needs. This new program identified $163M of malpositioned equipment for redistribution in December 2004, $208M in March 2005, and $220M in September 2005.

LMI's semiannual program is a good start, but the Air Force needs a near-real-time method to redistribute equipment. The Air Force redistribution program should identify a malpositioned asset when it becomes available or when a requirement is identified that a malpositioned asset can satisfy. The Air Force also needs a tenable transaction process to redistribute a malpositioned asset where it is needed. The Air Force redistribution program should use the business rules we developed, but it should process the transactions immediately.

Repair

The spares community uses EXPRESS to determine what to repair every day. The Air Force equipment community does not have a product that identifies if there are unserviceable equipment assets with a valid need that are not yet inducted for repair. No central repair office determines what equipment needs to be repaired and what is keeping items from induction. Again, the computation applies unserviceable items to valid needs, and failure to repair, or a delay, means a valid need goes unfilled.

We developed an automated program that identifies unserviceable equipment with a valid need (a current requisition). Table 5 summarizes the results as of October 2005.

The Air Force Equipment Management System (AFEMS) shows unserviceable equipment accounts for $465M in repair costs, $49M of which equates to a current need which is applied in the Air Force equipment computation. A total of $44M of assets applied to a need are not on work order or not inducted, and $25M of those assets have an outstanding requisition.

The Warner-Robins program prioritizes a list of items that need repair, known as the repair backlog. The air logistics centers should use this list to induct equipment into repair or correct source data systems if items are in repair and the data is incorrect. If the data is accurate and the item cannot be inducted, the central repair office should manage the item and take steps to remove any constraints to induction. The repair backlog listing will be run monthly—more often if necessary early in the fiscal year—and provided to the ALCs.

The Air Force needs to find a multiple-user computer system to host the repair program, so the item managers and production specialists can provide feedback on the actions they take to induct equipment items in need of repair. LMI will continue to look for a system for the repair backlog list and develop procedures to manage equipment repair. Our program provides the business rules that should eventually be incorporated into the equipment requirements and execution system, whether it is ERS, AFEMS, or the Expeditionary Combat Support System.

Replacement Forecasting

LMI analyzed how the Air Force forecasts replacement requirements and found it has no way to forecast replacement requirements effectively. The current Air Force system does not collect the data needed to provide an accurate forecast. Even with more complete data, we doubt any system could forecast equipment replacement needs accurately enough at the national stock number level to risk buying in anticipation of a need.

In March 2003 the current system forecasted $350M worth of items that did not fail, and did not forecast $260M of items that did fail. There was a total of $568M of items with a replacement requisition that were not included in the computation. For some items, equipment users requisition items to replace, but retain the current equipment until the replacement is received. These replacement requisitions are not included in the computation unless the item manager forecasts a replacement factor or includes an additive requirement in the computation. We developed a program to identify the replacement requisitions that are not included in the computation and create transactions to load them as additives. This will ensure the computation includes all valid replacement requirements.

Summary

By using lessons learned from the spares community, LMI developed interim tools the Air Force can use to ensure the assumptions in the computation are effectively followed. The Air Force equipment computation applies assets to meet valid needs, but the Air Force does not ensure items are repaired or redistributed to meet those needs. The Air Force needs tools to execute (buy, repair, distribute, redistribute, and allocate funds) the computation.

LMI's interim tools provide the logic necessary to execute a requirement, and we have achieved significant results. The tools have nearly doubled the number of organizations with a 90 percent fill rate (S-1 fill rate goal). Using these tools, the Air Force identified more than $220M of improperly positioned equipment, and took action to either correct the data or ship the equipment to where it was needed.

The LMI-developed tools have also identified items awaiting distribution and repair, thereby reducing the customer wait time. However effective these tools are, they are only a provisional measure. The Air Force needs to incorporate LMI's business logic into near-real-time systems that will make accurate and effective decisions daily instead of periodically.

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Analyzing OCONUS Port-Handling Charges

Master Sergeant Daniel J. Bender, USAF

The Air Force ships cargo every day. Traffic managers are entrusted to move government property within prescribed timeframes while ensuring economical use of transportation funds. But do we know what we get for our transportation bucks?

The process of moving cargo seems simple. Take an item you want shipped to the traffic management office (TMO). They package it, label it, and ship it. Simple! It's just like taking something to United Parcel Service (UPS) or Federal Express (FedEx) but you don't have to pay for the service, right? Wrong.

The movement of cargo may seem simple and *free* to the customer, but make no mistake—there is no such thing as free transportation. Before TMO accepts the item for shipment, they are supposed to receive a line of accounting (LOA) or transportation account code (TAC) which is an account number where the shipment costs eventually get charged.

Many years ago before automation and transportation systems, the *rule of thumb* was this: TMO must have a TAC—any TAC—but we (TMO) knew that the shipment would not move without a TAC. The TAC was a simple 4-digit alphanumeric code. We even had a generic TAC written on a piece of paper ready to use when a shipment didn't have a TAC already assigned. The generic TAC we used in technical school (and at my first few bases) was F8A0. Everyone in the TMO community could relate to F8A0. We could move anything with that magic TAC.

As *worker bees* at the base level surface freight section, we never saw any monetary transactions take place. We knew by placing a TAC code on the paperwork the item made it to its final destination, but we didn't know at what price.

The generic TAC F8A0, and most other TACs for that matter, was really used to charge against the Air Force's Second Destination Transportation (SDT) budget. The SDT budget is a big pot of money called a centrally-managed allotment and is managed by Air Force Materiel Command (AFMC). Today over 40 different TACs bill against the SDT budget.

It is the combination of the TAC and local transportation operating funds that is used to ship cargo. The costs of packaging and labor are incurred by the local TMO operating funds. Most small parcel transportation services (for example, FedEx, UPS, and DHL) and some line-haul charges (over-the-road trucks and trailers) for domestic shipments are also paid for by the local TMO.

So what exactly does the TAC pay for? In very basic terms it includes the direct and some indirect transportation costs. The transportation charges for overseas shipments are directly charged to the TAC by either Surface Deployment and Distribution Command (SDDC) or Air Mobility Command. A rate structure is used to charge the cost of transportation (truck, aircraft, or vessel) by weight of the shipment. This is known as a direct cost that can be attributed to that single piece of cargo. However, the transportation cost is not all inclusive of other charges for accessorial services required to move the cargo to its destination. An example of an accessorial charge would be port handling.

Port handling is the cost related to having the cargo loaded on and unloaded off a vessel at a water port. Normally the military does not have personnel who perform these services so they contract the services of a stevedore company. Because stevedores are hired for the port, different companies are normally contracted at each port of embarkation and port of debarkation. Therefore the costs of these services may vary from port to port.

Stevedore companies charge the military direct costs relating to either the loading or unloading operation. They break down the cost of man-hours, supervision, and equipment used. Every

Article Acronyms

AFMC - Air Force Materiel Command
CONUS - Continental United States
DFAS - Defense Finance and Accounting Service
DoD - Department of Defense
DTR - Defense Transportation Regulation
FedEx - Federal Express
FY - Fiscal Year
LOA - Line of Accountability
MAJCOM - Major Command
SDDC - Surface Deployment and Distribution Command
SDT - Second Destination Transportation
TAC - Transportation Account Code
TCN - Transportation Control Number
TFMS - Transportation Financial Management System
TMO - Traffic Management Office
WPLO - Water Port Liaison Office
UPS - United Parcel Service

operation for each vessel could incur a different cost. Trying to charge the individual piece of cargo to an actual cost of port handling would be very tedious, challenging, and inconsistent for shipment planning purposes.

The SDDC has overcome this problem by agreeing to pay the direct cost of the stevedores and then accessing the port-handling charges to the shipper based on a rate structure by measurement tons. They publish a rate cost structure for each port used around the world since stevedore charges vary from port to port.

The SDDC normally charged the port-handling costs to the shipper through the same TAC as the over-ocean costs were charged. The Air Force had exceptions to this policy. It is not known exactly why, but the Air Force required overseas major commands (MAJCOM) to fund and pay some of the overseas port-handling charges, rather than having the costs charged to the TAC. It is important to note that this business rule only applies to overseas MAJCOMs (United States Air Force Central Command, United States Pacific Air Forces, and United States Air Forces in Europe). This does not apply to the continental United States (CONUS)-based ports where the TAC pays for the port-handling charges. AFMC owns and funds the second destination transportation (SDT) TACs that are used for most shipments. Because of this irregularity, MAJCOMs used their water port liaison offices (WPLOs) to determine overseas port-handling charges and reimburse SDDC directly through the Defense Finance and Accounting Service (DFAS).

The WPLOs received a monthly billing statement from DFAS provided by SDDC that included all Air Force transactions for every water port. The WPLOs verified and reconciled the bill and provided their fund cites to pay for the valid port-handling charges. This was a manual process, as not every shipment followed the rules of the AFMC SDT TACs. There were some Air Force TACs that should have included the port-handling charges in their transportation costs.

This manual method was used for many years. However, in 2003, automation changed things. The SDDC implemented a new financial system called the Transportation Financial Management System (TFMS). TFMS was designed around the business rules of the Defense Transportation Regulation (DTR). The DTR basically defined the TAC as the single line of accounting to which all transportation costs related to the shipment move would be charged. Therefore, TFMS was designed to allow only a single TAC or LOA to be used for each transportation control number (TCN). This change was unnoticeable to all Department of Defense (DoD) customers, with the exception of the Air Force.

The overseas WPLOs noticed that they were no longer receiving monthly billing statements from DFAS and their MAJCOM funding for port-handling costs were not being charged. No one knew what changes were taking place. Did SDDC stop charging for port handling? Was there an unusually long delay in the billing process? Was the bill going to another address? No one knew.

The Air Force Logistics Management Agency was commissioned to answer the mystery of the disappearing bills. During the data-gathering process, we discovered that TFMS was billing all transportation charges to the TAC as it was designed to do. After discussions with SDDC, it was discovered that TFMS could not accommodate the unique payment business rules of the Air Force.

This posed a fiscal problem for the Air Force. Funds obligated by overseas MAJCOMs to pay the port-handling charges were lost through lack of use. The SDT fund was severely constrained because unexpected port-handling charges were included in the overall transportation cost. This constraint meant shipments had to be restricted from movement when there were critical funds shortages. This fiscal dilemma continued for two fiscal years (FY)—FY04 and FY05.

The SDDC learned of the problem in FY06. To assist the Air Force, it developed an exceptions list that could be generated against the TFMS billing process. This exceptions list is a manual method that keys in on overseas port codes and creates a listing of port-handling charges assigned to those codes. This exception list process was used in FY06 to dampen the economic impact for funds already authorized for that year. Separate bills were issued to overseas MAJCOMs, specifically for port-handling charges as they had prior to FY04.

This manual *fix* is not a flawless method. It requires personnel at SDDC and the WPLOs to manually verify the data and segregate those transactions where the TAC either pays or doesn't pay the port-handling charges. Although the majority of shipments utilize an SDT TAC, there are many others that should not be paid for by the MAJCOM accounts. For example, the exceptions listing only searches for TACs beginning with the letter F. This includes all Air Force shipments, but it also includes Air Force Guard and Reserve TACs as well. The overseas MAJCOMs do not pay port-handling for Guard and Reserve cargo. Both the Guard and Reserve pay port-handling through their own TACs just like the rest of the DoD. Additionally, there are Air Force working capital funded items that also pay the port-handling charges through the appropriate TACs. All of those instances need to be returned to DFAS and SDDC to be rebilled to the correct TAC. Anytime there is manual manipulation of data, the chances of error increases.

What is the best way for the Air Force to pay the overseas port-handling charges? There are several options. They have pros and cons. The SDDC would like to allow TFMS to bill as designed and as indicated by the DTR published at the time of design. An interesting note is the DTR was revised in early 2005 to include the new business rules set by AFMC regarding Air Force payments of overseas port-handling charges by overseas MAJCOMs.

If the Air Force prefers to have the overseas MAJCOMs pay the overseas port handling, then SDDC will be asked to continue to provide manual billing support. This manual support could result in an increase of annual surcharge funds for the Air Force. The manual exceptions list will still result in the manual process of validating and rebilling the Guard and Reserve components bills, as well as the Air Force working capital funded shipments. If any of these transactions are overlooked by WPLO personnel, the overseas MAJCOMs will bear the additional cost of the loss. If there were no human error, the SDT budget would not be constrained due to the port-handling charges.

If SDDC were to bill against the TAC, the Air Force would have to make provisions for the rising cost of transportation and an increased budget for the SDT fund. Although it may seem like the pressure is on AFMC to conform to the way the DoD uses the TAC for all transportation costs provided by SDDC, the funds in the SDT and overseas MAJCOM budgets could be realigned. There would be an elimination of the manual process

providing more accurate billing. There would be no chance for error of port-handling charges against MAJCOM or SDT funds for the Guard or Reserve component or Air Force working capital funded shipments. It would lead to the elimination of the MAJCOMs requiring a port-handling budget.

The Air Force should take a long hard look at the way we pay port-handling charges. We should strive for accuracy in billing, eliminate unnecessary budgets, and properly obligate funds where services are rendered. When we have resolved this confusion and conflict, then and only then, can we honestly know who's paying the bill.

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Charles E. Taylor: Aviation's Unsung Hero

Kenneth MacTiernan, AMTA Director

An aircraft has a mechanical discrepancy and the man, or woman, you call is a skilled, trained aircraft maintenance technician (AMT). This professional investigates the fault, and before you know it, the problem is solved, the logbook is signed off, and the aircraft is returned to airworthy status. This scenario happens countless times at airports around the world 24/7, 365 days a year. This scenario, regardless of the severity of the discrepancy, does not differentiate between military, commercial, corporate, government, or general aviation aircraft. An aircraft is a technical piece of equipment, and the men and women who work on these modern marvels of engineering are, for the most part, taken for granted. Everybody knows that the AMT is skilled, knowledgeable, and professional. But does everybody know where these AMTs came from? Do they wonder who started the craft of the aircraft maintenance technician? Where did the basic principles of this demanding profession originate?

The world knows about mankind's first controlled, powered flight. Both Orville and Wilbur Wright are household names because their imagination and technical abilities allowed them to lay claim to the first manned powered flight—a rather impressive feather to have in one's cap. But who helped them achieve this milestone in mankind's history?

Unfortunately, the world knows little of the man that helped the Wright brothers and our country achieve this point in aviation's history. This man was Charles E. Taylor. Mr Taylor was a self-taught Midwestern mechanic, who worked for the Wright brothers in their bicycle shop. Charlie is considered the *unsung hero* of aviation because he was asked to build the first engines for the Wright Flyer. He met specifications requiring that the engine should produce 8 brake horsepower[1] and not weigh more than 200 pounds. Asked if he could produce such an engine, Charles E. Taylor simply replied, "Yes."

In roughly 6 weeks and working with a block of steel, the bicycle shop's lathe, drill press, and some simple hand tools, Taylor would make history. Because of the knowledge, skill, and integrity Mr Taylor possessed, the Wright Glider would become the Wright Flyer. Ohio and North Carolina would be the bases from which mankind would take the first manned, controlled, powered flight.

Article Acronyms

AMT - Aircraft Maintenance Technican
AMTA - Aircraft Maintenace Technican Association
FAA - Federal Aviation Administration

On December 17, 1903 when the Wrights took their first step into aviation history, Charlie was not there. He was back in the bicycle shop *minding the store*. Charlie knew his engine would work and stayed behind. But little do people know that Charlie made more than the first engines for the Wright Flyer. His skill was also used in manufacturing and repairing many of the components for the Flyer itself. One example is when Charlie repaired the propeller shafts after screws were jerked loose by using heavier gauge steel tubing. When parts needed attention that could not be addressed on the Kitty Hawk site, these parts were sent back to Charlie in the bicycle shop for repair.

After the Wrights successful flight, Charlie's knowledge, skill and integrity were needed even more. The Wrights would eventually need a larger engine, which of course was a task given to Charles E. Taylor. After necessary changes were made to new engine castings, Charlie built the 1904 engine with cylinders 1/8 inch thicker.

After the *problem* of flight was conquered, an area closer to the Ohio bicycle shop was needed for operations and improvements. It was then that 100 acres of prairie north of Dayton, now part of Wright-Patterson Air Force Base, called Huffman Prairie after its owner, became the first airport. But a prairie wasn't the ideal locale for an aircraft. Barbed wire fences, grassy hummocks, and such were all around the area. At this point in time it is, once again, Charles E. Taylor who assumes the responsibilities of an airport manager and getting things done. He dealt with unique problems, such as the assembling and maintaining of a shed, or an early-day hangar, in which the first Wright aircraft could be stored.

After twice being ignored by the United States government to examine their machine for possible military applications, the Wright brothers decided to take their new invention to Europe. They once again turned to their *aircraft mechanic* who was given the responsibility of crating the Wright Flyer for shipment across the globe to both England and France. This task was accomplished in a shed and then the Flyer was shipped to the East Coast by train. After the Wright Flyer made the journey to Europe, it was again Charles E. Taylor who was responsible for assembling the craft.

After the Wright's return to the United States, Calbraith (Cal) Perry Rodgers, grandson of Commodore Calbraith Perry whose *gunboat diplomacy* opened Japan to the West, decided to make an attempt at transcontinental flight. Once again, it was Charlie who was looked at to be Cal's chief mechanic for this historic attempt. But before working for Cal on the *Vin–Fiz Flyer*, named after the first bottled grape drink of Cal's sponsor for this event,

Charlie checked with the Wrights because, with so few Wright aircraft, Charlie's knowledge was crucial to have around. Orville and Wilbur consented to give Charlie a leave of absence.

With Taylor participating in such a historic achievement, one would think his name would be mentioned in the same breath and sentence with Orville and Wilbur Wright, but such is not the case. Although the Wrights gave credit to Charlie for his contribution, he never searched for the limelight or to cash in on his notoriety. He had a job to do and he did it, just like today's AMTs. With the death of the Wright brothers and the rapid growth in both engine and airframe technology, Charles E. Taylor simply became a forgotten name. He became aviation's original *Unsung Hero*.

After 100 years of controlled, powered flight it is time that Charles E. Taylor be remembered and recognized for what he did and for the vocation he inspired—today's aircraft maintenance technicians. One organization trying to educate the public about Charles E. Taylor's proud place in aviation's history, and the men and women who have followed in his footsteps, is the Aircraft Maintenance Technicians Association (AMTA). The AMTA is a nonprofit organization and is open to all with a love of aviation. Their Web site is www.AMTAUSA.com. One of the ways the AMTA is helping to remember Charlie for his contributions is by donating bronze busts of his likeness at aerospace museums across the country. They have already donated one to the San Diego Aerospace Museum and plan others for the Smithsonian National Air and Space Museum and the National Aviation Hall of Fame.

The AMTA also has a program called the *Faces Behind Safety* which highlights AMTs from across the industry so the public can see and read about today's AMTs and how they follow in Charlie's footsteps.

With the leadership of Richard Dilbeck, Federal Aviation Administration (FAA) Aviation Safety Program Manager, Airworthiness, resolutions are being passed that recognize 24 May of each year as Aviation Maintenance Technician Day. This is in honor of Charles E. Taylor's birthday. Thanks to Mr Dilbeck, the State of California was the first to pass a resolution, and now 30 more states are in the process of passing similar resolutions. A national resolution is under way, thanks in large part to the Professional Aviation Maintenance Association and their president Brian Finnegan. With this day set aside as a day to honor Charles E. Taylor, and today's AMTs, recognition is forthcoming.

Last year, Embry-Riddle Aeronautical University in Daytona Beach, Florida renamed their maintenance program the Charles Taylor Department of Aviation Maintenance Science in honor of Mr Taylor and dedicated a bronze bust of Charlie during a daytime barbecue and nighttime formal dinner. This was done in large part due to the determination of Aviation Maintenance Science Department Chairman Fred Mirgle.

Frontier Airlines, under the guidance of Tom Hendershot, celebrates 24 May by sponsoring barbecues for their AMTs across their system. Last year the AMTA held their first AMT Day Celebration at Spanish Landing in San Diego, California.

There is also a very informative book written by Howard R. DuFour titled, *Charles E. Taylor: The Wright Brothers Mechanician*. This book portrays not only what Charlie did for aviation, but also his colorful life. It is a must for any aviation enthusiast's library.

The FAA has a program called the Charles E. Taylor Master Mechanic Award. This award is given to any aircraft maintenance technician, who has a minimum of 50 years in aviation, has been licensed for at least 30 of those years, and has never had his license revoked or negative action taken against him, and is recognized for his contributions to aviation. To be considered for this prestigious award, an individual must be nominated by three separate people in writing, detailing the reasons the person deserves an award named for the *father of aircraft maintenance*.

So, the next time an aircraft has a mechanical discrepancy, remember that the man or woman you call to inspect and repair the fault is a person who follows in the footsteps of a man who looked at his craft with respect and passion. Aircraft maintenance technicians use knowledge, skill, and integrity as the basis for their craft. They do not look for notoriety or the spotlight. They carry a great responsibility, and they pass that responsibility on from generation to generation. They are aircraft maintenance technicians! Thanks to Charles E. Taylor!

Notes

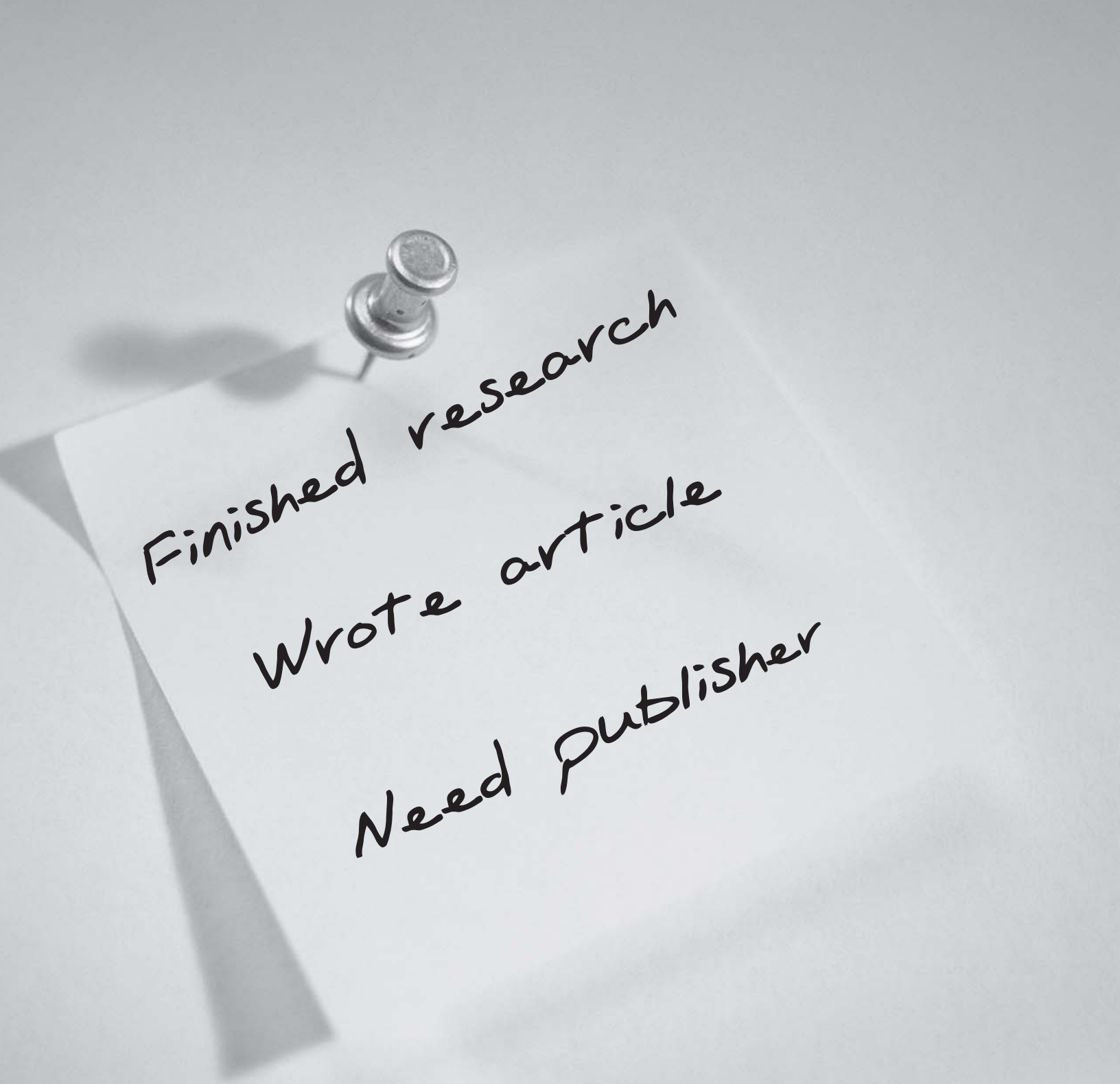
1. Brake Horsepower: The measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliaries.

Kenneth MacTiernan is the founder and director of the Aircraft Maintenance Technicians Association. He served in the United States Air Force from 1981 to 1985 as a B-52 mechanic. He is also a 20-year aviation maintenance technician for American Airlines.

notable quotes

I said to myself, I have things in my head that are not like what anyone has taught me—shapes and ideas so near to me—so natural to my way of being and thinking that it hasn't occurred to me to put them down. I decided to start anew, to strip away what I had been taught.

—Georgia O'Keeffe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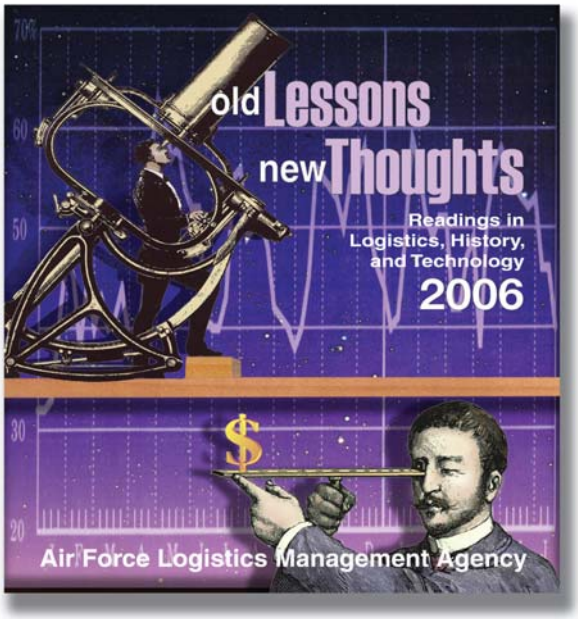

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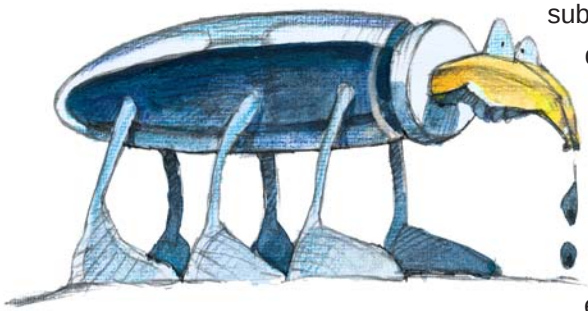
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