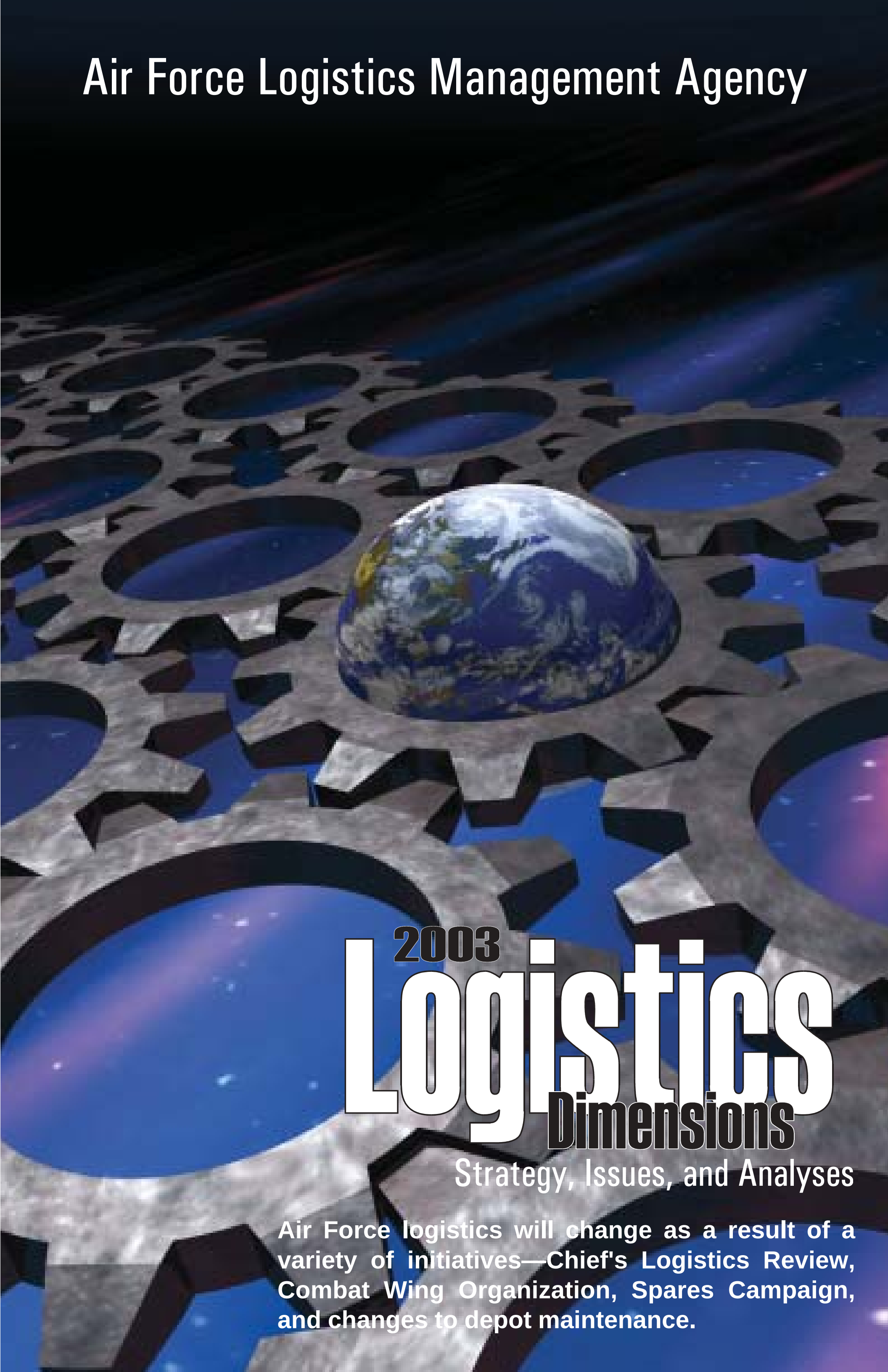


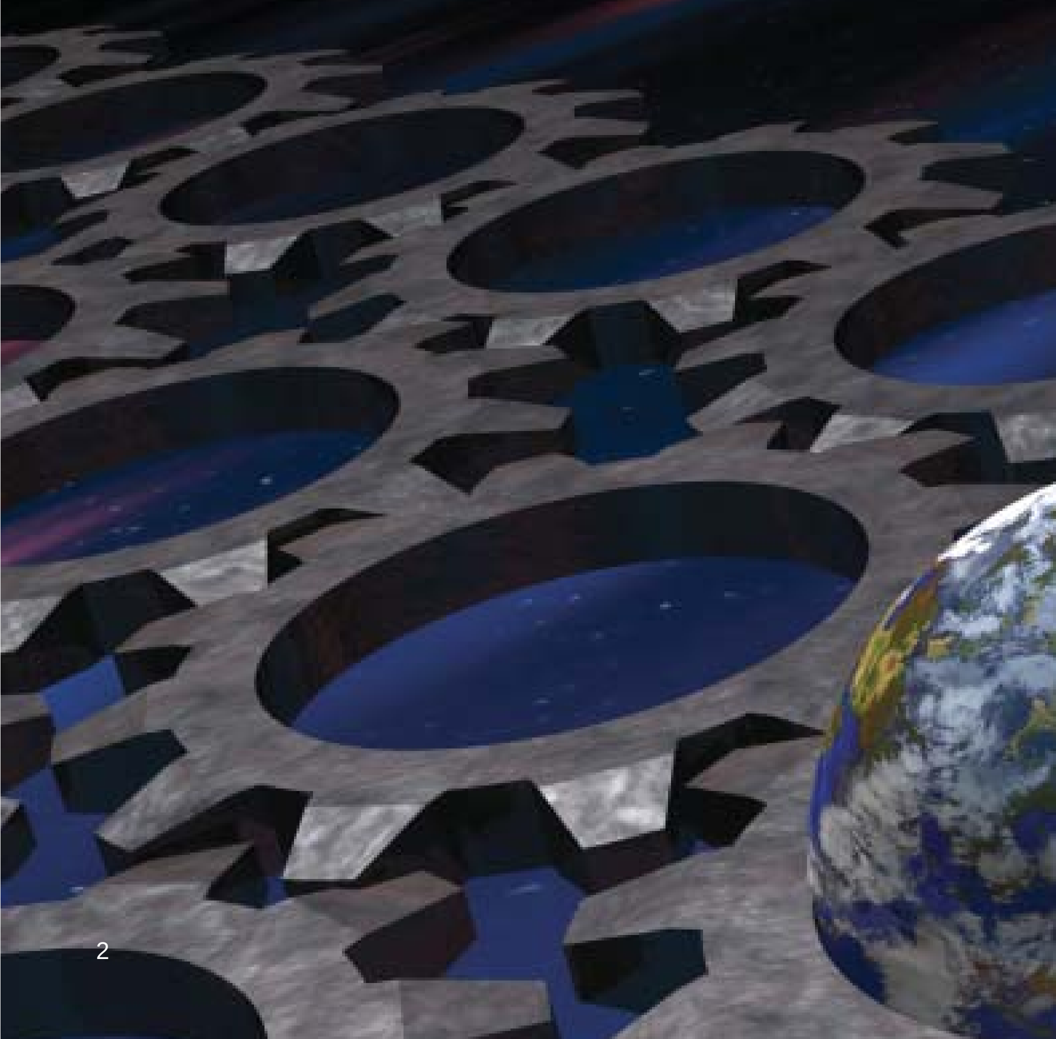
Air Force Logistics Management Agency

2003 Logistics Dimensions

Strategy, Issues, and Analyses

Air Force logistics will change as a result of a variety of initiatives—Chief's Logistics Review, Combat Wing Organization, Spares Campaign, and changes to depot maintenance.

2003 Logistics Dimensions



Articles, Essays, and Studies

Logistics Dimensions Vignettes

The Editors, Air Force Journal of Logistics

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Air Force Logistics Management Agency
501 Ward Street
Maxwell AFB, Gunter Annex, Alabama 36114-3236
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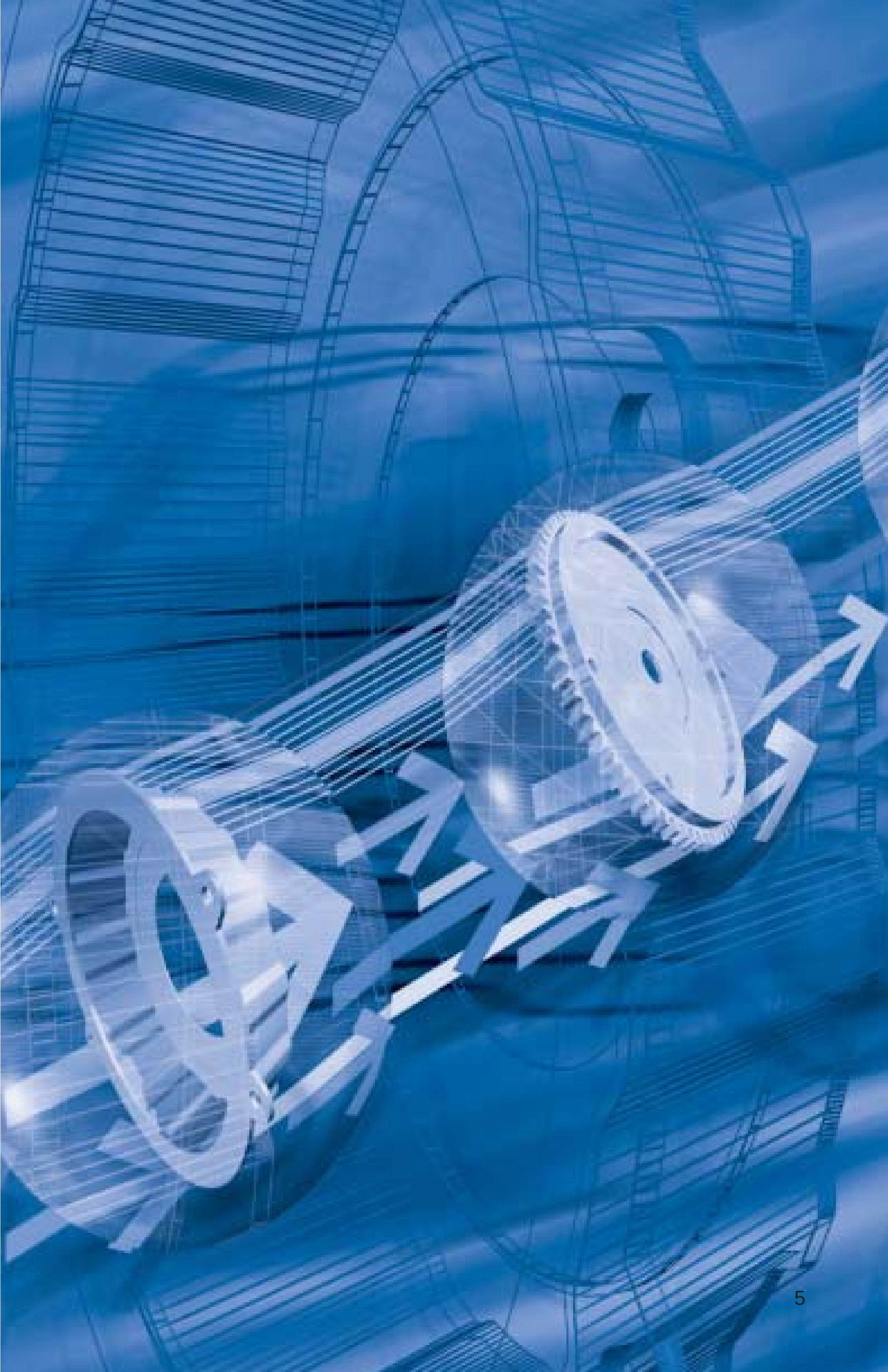
Cover, Layout, and Design
James C. Rainey and Beth F. Scott

Introduction

Logistics Dimensions 2003

Two concepts dominate Air Force logistics today: Focused Logistics at the joint level and Agile Combat Support within the Air Force.

Today's military faces many challenges, particularly in the area of logistics. Military forces are no longer dedicated solely to deterring aggression but must respond to and support a variety of combat and humanitarian missions. From peacekeeping, to feeding starving nations, to Homeland Defense, the military must continue to adapt to evolving missions and working with a broad range of allies or coalition partners. Logistics infrastructure and processes must evolve to support the new spectrum of demands and challenges. New technological advances must be capitalized and integrated into the support infrastructure. Similarly, the logistics community must examine existing processes through a variety of studies and analyses and look for ways to make quantitative and qualitative improvements. Accepted theories, practices, and processes need to be examined and, where necessary, challenged and changed. Two concepts dominate Air Force logistics today: Focused Logistics at the joint level and Agile Combat Support within the Air Force. The vision of both these concepts is the ability to fuse information, transportation, and other logistics technologies to provide rapid



While small, Logistics Dimensions 2003 addresses several of the major issues and challenges facing Air Force logistics.

response, track and shift assets while en route, and deliver tailored logistics packages at all levels of operations or war. This same vision includes enhanced transportation, mobility, and pinpoint delivery systems.

Air Force logistics will also change as a result of a variety of initiatives—for example, Chief's Logistics Review, Combat Wing Organization, Spares Campaign, and changes to depot maintenance.

Logistics Dimensions 2003 is a collection of essays, articles, and studies that lets the reader look broadly at many of the issues associated with the expeditionary air force of the 21st century. While small, *Logistics Dimensions 2003* addresses several of the major issues and challenges facing Air Force logistics. The content was selected to both represent the diversity of the challenges faced and stimulate discussion about these challenges. Also included is a short history of US aircraft production, 1916-1918.

Additional copies of *Logistics Dimensions 2003* are available at the Office of the Air Force Journal of Logistics.

Air Force Journal of Logistics
501 Ward Street
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Generating Solutions Today, Shaping Tomorrow's Logistics

Since its inception, the Air Force Logistics Management Agency has grown to be recognized for its excellence—excellence in providing answers to the toughest logistics problems. And that's our focus today—tackling and solving the toughest logistics problems and questions facing the Air Force. It's also our focus for the future.

Lots of organizations have catchy mottoes. Likewise, many have catchy vision statements. We do, too. But there's a big difference—we deliver on what we promise. *Generating Solutions Today, Shaping Tomorrow's Logistics* aren't just words to us; they're our organizational culture. We use a broad range of functional, analytical, and scientific expertise to produce innovative solutions to problems and design new or improved concepts, methods, systems, or policies that improve peacetime readiness and build war-winning logistics capabilities.

Our key strength is our people. They're all professionals from logistics functions, operational analysis sections, and computer-programming shops. Virtually all of them have advanced degrees, some of which are doctorates. But more important, virtually all of them have recent field experience. *They've been there and done that*. They have the kind of experience that lets us blend innovation and new technology with real-world common sense and moxie. It's also the kind of training and experience you won't find with our competitors. Our special blend of problem-solving capabilities is available to every logistician in the Air Force.

Our track record puts us in the lead in delivering robust, tailored answers to the most difficult and complex Air Force logistics problems. This can be seen in our efforts and partnerships that are turning expeditionary airpower support concepts into real-world capability. It can also be seen in our work in making dramatic improvements to the Air Force supply system and developing high-impact logistics publications and our leadership in planning and making logistics play in wargames, simulations, and exercises truly meaningful. The message is also loud—we work the important projects that shape tomorrow's Air Force, and we deliver what our customers need today!


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Consumable-item management in Air Force depots has evolved over the years, very dramatically in the last 5. The exclusive use of the economic order quantity (EOQ) model, for both leveling and ordering, has given way to more frequent ordering and, recently, to customer service-based leveling. This article documents the major milestones in that evolution, explains the reasons for them, and describes where the various pieces fit into the *big picture*. It presents a top-level description of the theory behind the systems in use and how they interact in the world of consumable inventory management. Before discussing the various pieces of the consumable management pie in more detail, however, a macroview view of the evolution of the whole system will help put the discussion into context. Figure 1 illustrates this evolution graphically from two perspectives. First, it divides the inventory management function into its three primary functions: forecasting, establishing stock levels, and ordering. In this way, the various techniques can be discussed in terms of their specific role. Second, it provides a chronological time line to help in understanding the order of evolution. The overview that follows explains Figure 1 in more detail.

Managing Air Force Depot Consumables

the big picture

Major Kevin Gaudette, USAF
Douglas Blazer, PhD
H. Kenneth Alcorn

Until a few years ago, the EOQ model was used to calculate stock levels and place orders, while the forecasts used to calculate the levels and reorder point were based solely on historical demands. In 1998, the Air Force Logistics Management Agency (AFLMA) published the results of a study that recommended more frequent ordering for some consumable items, for reasons that will be discussed later.[1] This led

to a change in policy, and the Air Force Materiel Command (AFMC) began ordering exactly what was used of each item at the end of each day. At about the same time, the Reparability Forecast Model (RFM) was being implemented on a limited basis at the air logistics centers (ALC).[2] RFM was originally developed a few years earlier as a forecasting tool to help identify shortages prior to production and is used to augment the ordering function with more accurate forecasts. Since it works independently of leveling and ordering systems, it complements whatever system is used for those functions. Finally, in 2001, AFMC unveiled the Customer-Oriented Leveling Technique (COLT) to replace EOQ levels. COLT uses a methodology similar to that used by the Aircraft Availability Model (AAM) for reparables, calculating levels to minimize the customer wait time. In this way, it ties levels to a customer-oriented measure of service, just as AAM is tied to aircraft availability.[3] COLT only recently has been tested and is currently being implemented.

The remainder of this article begins with a brief overview of EOQ theory, to include some of its assumptions. It also presents a discussion of the effects of violating those assumptions, which provides a framework for the subsequent discussion of solutions the Air Force has implemented over time. Safety levels, daily ordering, the Reparability Forecast Model, and COLT are all included in the discussion.

Economic Order Quantity

Until recently, the Air Force relied primarily on Wilson's EOQ model (via the Wholesale and Retail Receiving and Shipping Program [D035K]) and Standard Base Supply System [SBSS]) to manage its consumable inventory. The model has been widely used for decades, particularly for low-cost items. In fact, it was originally developed by F. W. Harris in 1915, making it one of the oldest inventory models in use today.[4] The fundamental objective of the EOQ model is to minimize total annual inventory cost—purchase cost of the item, cost to stock the item (its *holding cost*), and cost to order the item (its *ordering cost*).[5] Equation 1[6] presents the mathematical representation of the model.

Until recently, the Air Force relied primarily on Wilson's EOQ model (via the Wholesale and Retail Receiving and Shipping Program [D035K]) and Standard Base Supply System [SBSS]) to manage its consumable inventory.

$$\text{Total Annual Cost} = DC_U + \frac{D}{Q}C_O + \frac{Q}{2}C_H \quad (1)$$

Where:

	D	= *Forecasted annual dmand, in units*
	Q	= *Order quantity per order*
	C_U	= *Unit cost (price) of an item*
	C_O	= *Ordering cost per order*
	C_H	= *Annual holding cost per unit*

Equation 1

Equation 1 can now be differentiated with respect to Q and set equal to zero, which corresponds to the point on the total cost curve where the slope is zero. This point also represents the minimum annual cost, indicated in Figure 2 by a star. The order quantity Q corresponding to this minimum cost is known as the economic order quantity. It is also commonly represented by Q*, to denote that it is the value of Q that provides the minimum total cost shown in Equation 2.

$$Q^* = \sqrt{\frac{2DC_O}{C_H}}$$

Equation 2[7]

Using the basic EOQ model, up to Q* units are ordered for each consumable item each time the inventory drops below a level called the *reorder point*. Assuming the lead time is known and constant (a faulty assumption which will be discussed in more detail later), the reorder point is set at the level of demand during lead time, which ensures adequate stock is on hand while waiting for an order to arrive. As long as the assumptions are met, this technique minimizes the annual cost and ensures a minimum service level. Problems arise, however, when considering the sometimes-unrealistic assumptions of the model. Although there are many assumptions embedded in the EOQ model, five are listed in Table 1 and provide a framework for the remaining discussion of violating the assumptions and the solutions the Air Force has implemented to counteract those effects.

The fundamental objective of the EOQ model is to minimize total annual inventory cost—purchase cost of the item, cost to stock the item (its holding cost*), and cost to order the item (its* ordering cost*).*

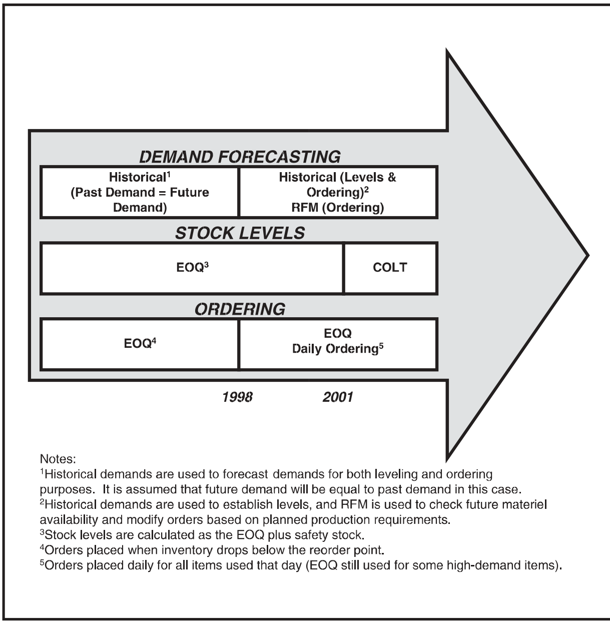

Figure 1. Evolution of Air Force Depot-Consumable Item Management

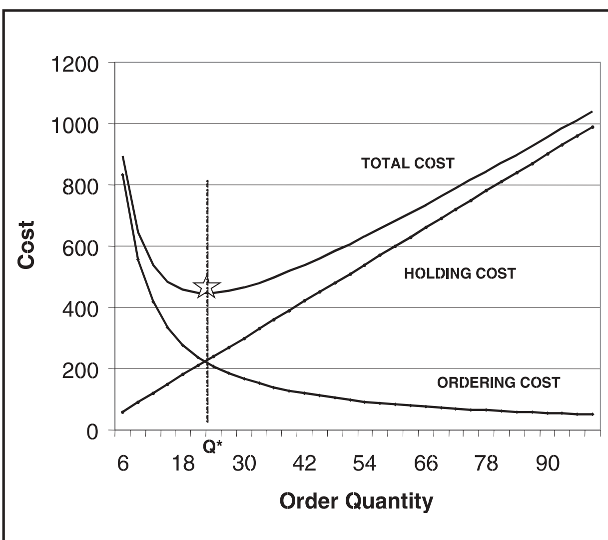

Figure 2. Cost Tradeoff Curve to Determine Economic Order Quantity Q*

EOQ Level Assumption	Reality	Air Force Solution
Known and constant lead time	Uncertain and variable	Safety levels
Known and constant demand	Highly variable	Safety levels RFM
Independent demand	Some demand dependent	RFM
Single echelon	Multiechelon, with each echelon using EOQ batches	COLT Daily ordering at ALCs
Known ordering and holding costs	Varies by item and is difficult to estimate in practice (see text discussion)	Flat-rate estimates

Table 1. EOQ Assumptions and Corresponding Air Force Solutions

EOQ Assumption Violations, Their Effects, and Air Force Solutions

Assumption 1: Known and Constant Lead Time (Solution: Safety Stock). Of all the assumptions known and constant, lead time is perhaps the most often violated and most often studied. Consider the *sawtooth* diagram in Figure 3, which shows the steady depletion of inventory over time, the order of quantity Q* when inventory reaches the reorder point, and the subsequent replenishment of inventory up to Q* when the order arrives. As noted in the diagram by the dashed line, a longer lead time than anticipated results in a stockout situation, since the stock goes to zero prior to the order arrival and any demands, therefore, become back orders.[8]

The most common remedy for uncertain and variable lead times, the one that has historically been used by the Air Force, is the use of safety stock.[9] Safety stock is simply a buffer of inventory carried in addition to the normal level, which exists for the sole purpose of reducing the chance of back orders when the lead time or demand, as will be discussed in the next section, is greater than anticipated. In Figure 4, the stockout from Figure 3 is repeated, but in this case, the safety stock is available to meet demands until the order is received.

The most common remedy for uncertain and variable lead times, the one that has historically been used by the Air Force, is the use of safety stock.

Violating the known and constant demand assumption has an effect similar to that of lead time, in that higher-than-anticipated demands during the lead time of an order will deplete stock more quickly than planned.

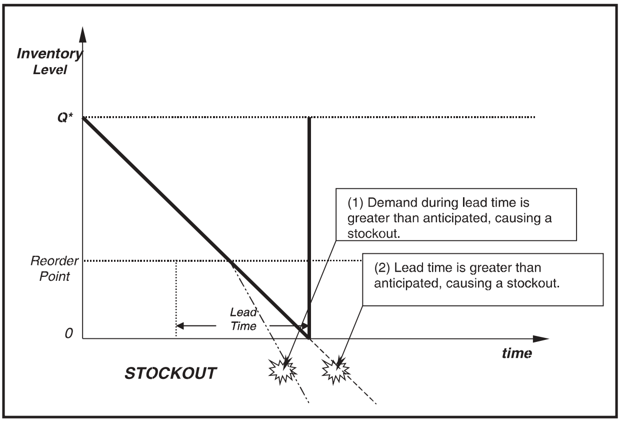

Figure 3. The Effects of Violating Known and Constant Demand and Known and Constant Lead-Time Assumptions

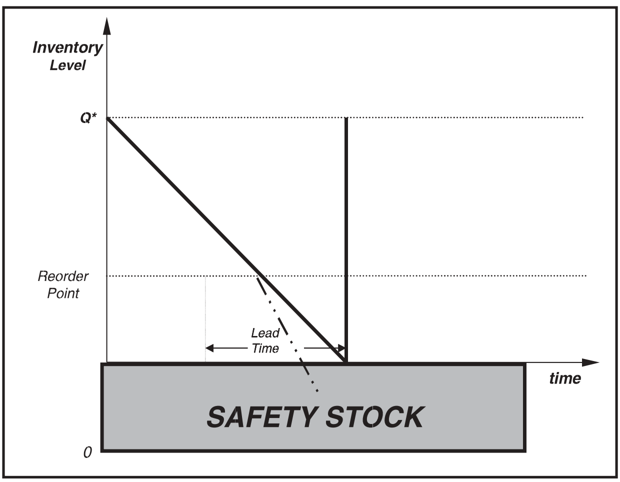

Figure 4. Adding Safety Stock Levels to Preclude Back Orders Due to Lead-Time Variability

Assumption 2: Known and Constant Demand (Solutions: Safety Stock and Reparability Forecast Model). Violating the known and constant demand assumption has an effect similar to that of lead time, in that higher-than-anticipated demands during the lead time of an order will deplete stock more quickly than planned. The result, as in the case of variable lead time, is a stockout.[10] Two solutions have been applied to this problem in the Air Force: safety stock and RFM. Safety stock is used for the same reason as lead time—to provide a buffer of inventory to reduce the chance of a back order in the face of variability. RFM is a more recent solution to the problem, having been implemented only over the last 5 years by AFMC in its air logistics centers. It provides materiel managers at the depots with a decision support tool to account for known variations in demand and adjust orders accordingly.[11] As RFM primarily addresses violations of the independent demand assumption, however, a more detailed discussion is reserved for that section.

Assumption 3: Independent Demand (Solution: Reparability Forecast Model). A third EOQ assumption systematically violated in the Air Force is independent demand. Independent demand is defined as demand "unrelated to the demand for other items."[12] Clearly, this is not the case with many Air Force consumables. For example, demand for turbine blades is directly related to the demand for jet engines. Although this violation is not always a problem, it is enough of a problem that production for many reparables is repeatedly and significantly delayed for want of a small number of consumable items.[13] Violating this assumption, especially its effects on production, led AFMC to develop the RFM.

Independent demand is defined as demand "unrelated to the demand for other items." Clearly, this is not the case with many Air Force consumables.

Reparability Forecast Model

Motivated by production delays caused by stockouts, the San Antonio ALC contracted with CACI to develop RFM to identify those parts that will hold up future production. RFM was subsequently implemented at the Oklahoma City ALC and later chosen by AFMC for inclusion in its standard suite of ALC systems. It has since been implemented, primarily for engines, at all the air logistics centers.

RFM actually addresses two problems: demand variability and demand dependence. With regard to the first, it provides depot materiel managers a tool to help cope with *anticipated* variations in demand. Although safety stock provides protection from these variations, it is still *blind* in the sense that it does not specifically

RFM actually addresses two problems: demand variability and demand dependence. With regard to the first, it provides depot materiel managers a tool to help cope with anticipated *variations in demand.*

account for individual, known fluctuations. Where the EOQ model assumes demand will be constant for the foreseeable future, in reality, demand fluctuates through time, often in ways that can be anticipated. A recent example was the dramatic increase in flying hours required for operations in Afghanistan. Since such a known increase in flying will certainly result in a greater number of repair actions, it is appropriate to have a system in place that can estimate the effect on consumable part requirements. To accomplish this estimate, RFM borrows the system logic of materiel requirements planning (MRP)[14] systems. In so doing, it addresses the second issue of dependent demand, since MRP systems calculate parts requirements dependent on requirements at the end-item level. RFM was, therefore, developed partly as a forecasting decision-support system to help identify times when the EOQ level will be inadequate.

RFM performs two primary functions:[15]

- It can provide an assessment of inventory availability, given the current projection of repairs in the Secondary Item Requirements System (D200A).
- It can provide the user with an estimate of shortfalls if the current projection changes (a *what if* analysis).
- In either case, materiel managers can generate special requisitions and expedite shipments to meet consumable demands for repairs. These special requisitions are generated automatically by RFM but are subject to review by depot materiel managers.

Assumption 4: Single Echelon System (Solution: Daily Ordering and COLT). A fourth critical assumption made by the EOQ model, which is violated in the Air Force depot environment, is that it operates in a single echelon system. This assumption basically implies that the SBSS (at bases) and D035K (at depots) order in batches of quantity Q* directly from suppliers. In reality, for consumable items, the depots order in batches of Q* from the Defense Logistics Agency (DLA), which, in turn, orders (also in batches of Q*) from suppliers. This additional echelon exacerbates the problem of demand variability, often severely, resulting in a problem known as the *bullwhip effect*,[16] meaning that demand variability gets worse as you move up the supply chain.

The Air Force developed two solutions to account for the multiechelon nature of its depot demand. The first was the result of an AFLMA study published in 1998, which found that more frequent ordering of some higher cost, low-demand consumables from DLA would help s*mooth* the demand that DLA sees.[17] AFMC responded with a policy of daily ordering of all consumables at the depots, which, although a more drastic step than AFLMA recommended, has allowed DLA to see actual Air Force demands more directly so less safety stock is required to account for variability. The second solution, only recently developed, is the COLT developed by AFMC.[18]

COLT was developed using the same mathematical logic as the AAM and Aircraft Sustainability Model (ASM) used in reparable inventory management.[19] The main difference lies in its objective. Where AAM and ASM seek to maximize the number of aircraft fully operational for a given inventory investment,[20] COLT seeks to minimize the customer wait time.[21] All three take a systems view of inventory management, accounting for multiple echelons of supply (in this case, bases, ALCs, and DLA). All three use a marginal analysis approach to determine which items and how many of each to stock, incrementally adding individual items to the inventory that provides the maximum *bang for the buck*. The biggest difference is in how *bang* is defined.

Assumption 5: Known Ordering and Holding Costs (Solution: Flat Rates). The final assumption discussed is known ordering and holding costs. In practice, these costs are extremely difficult to estimate and usually vary significantly from item to item. Ordering costs generally vary depending on the lot quantity and physical size of the shipment, and the lot quantity Q* calculated by the economic order quantity actually requires it as an input.[22] This circular logic reduces the model's effectiveness in minimizing costs. Holding cost is comprised of a number of components, the largest of which is known as the *opportunity cost*.[23] Essentially, the opportunity cost represents the benefit that could be gained by investing the money in something other than inventory. In commercial businesses, this opportunity cost is generally the interest that could be earned on a capital investment,

COLT was developed using the same mathematical logic as the AAM and ASM used in reparable inventory management.[19] The main difference lies in its objective.

The EOQ model has been in use for decades, because of its simplicity and ease of implementation. With the advent of affordable desktop computing power greater than that of older mainframes, more sophisticated models are now available that address many of EOQ's faulty assumptions.

usually referred to as the *hurdle rate*.[24] Since government organizations do not have tangible investments, holding cost becomes a nebulous concept. Quantifying the benefit of investing in an additional F-15 instead of inventory, for example, is nearly impossible. The Air Force, recognizing this difficulty, has historically used flat holding and ordering costs that apply to all items indiscriminately[25] and has been reluctant to change them because of their substantial impact on inventory levels. Without accurate costs, the EOQ model's attempt to minimize total cost is adversely affected. This is perhaps the least problematic assumption violation, since the total cost is actually relatively flat around the economic order quantity (Figure 2). This means that errors have a minimal effect on the total cost, relatively speaking.[26]

Conclusion

The EOQ model has been in use for decades, due mainly to its simplicity and ease of implementation. With the advent of affordable desktop computing power greater than that of older mainframes, more sophisticated models are now available that address many of EOQ's faulty assumptions. This article has discussed five of those assumptions, their effects, and steps the Air Force has taken to deal with those effects.

To protect against stockouts due to variability in demand and lead times, the Air Force has traditionally used safety stock levels but more recently has implemented RFM to help reduce its dependence on high safety stocks. RFM, regardless of the core system used to determine levels, plays a watchdog role that gives materiel managers visibility of impending stockouts and the ability to conduct *what if* analyses to cope with known demand changes. Daily ordering of consumables at the air logistics centers was implemented after a 1998 AFLMA study found that more frequent ordering of some consumables would reduce the *bullwhip effect* and allow DLA to provide higher service rates with less safety stock. The benefits, in most cases, outweighed the additional ordering cost associated with a greater number of orders. AFMC's development of the COLT model is its latest effort to transform Air Force-consumable inventory management and has proven to be a major step forward. The systems approach of COLT at last acknowledges the multiechelon, dependent nature of demands inherent in most Air Force items and makes inventory decisions based on a tangible and measurable impact to the customer.

Air Force depot-consumable management has gradually progressed from exclusive use of historical data (for forecasting) and the EOQ model (for leveling and ordering). The forecasting function, although still dependent on historical demand data, has been augmented with a more accurate RFM forecast. The leveling function has graduated from the economic order quantity to the recently developed COLT, taking customer wait time into consideration in the establishment of levels. Finally, the ordering function has changed from the batch ordering of economic order quantity to daily orders, providing DLA with a more accurate picture of Air Force demand. The future may well see further improvements and changes, but the last 7 years have brought more change to consumable inventory management than the Air Force has seen in many decades.

The forecasting function, although still dependent on historical demand data, has been augmented with a more accurate RFM forecast. The leveling function has graduated from the economic order quantity to the recently developed COLT, taking customer wait time into consideration in the establishment of levels.

Notes

1. Capt Buddy Berry, Capt Brad Anderson, Dr Douglas Blazer, John Dietz, and 1st Lt Severine Colborg, "Harmonization of Air Force and Defense Logistics Agency Economic Order Quantity Policies," Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama, Oct 98.
2. "Reparability Forecast Model," CACI briefing to OC-ALC/LPP, Oklahoma City ALC, Tinker AFB, Oklahoma, 21 May 97.
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Air Force Spares Campaign

Supply chain management and integration of the supply chain are concepts that have been growing in importance. The commercial sector has embraced them. An integrated supply chain network offers the Air Force a path to logistics transformation. Like many ideas, it seems easy in concept, but realization is the hard part. Supply chain management is complex like the Air Force logistics system. And like any complex system, supply chain management has limited value if it is used in an ad hoc fashion. To employ a concept like supply chain management for transformational purposes, it must first be defined. There are many definitions, all having the same general components. For instance, commercially, a supply chain is "An association of customers and suppliers who, working together yet in their own best interests, buy, convert, distribute, and sell goods and services among themselves, resulting in the creation of a specific product."[1]

Regardless of the specific definition, there are standard features of supply chain management. Essentially, it comes down to integrating the activities of all members of the supply chain network to optimize their collective performance to minimize cost, as well as the time between order and delivery of a product. It is the coordination and consistency of activities among the members of the supply chain network that matter. Coordination and consistency require purposeful design and engineering of supply chain networks. Synchronization of all members' activities is key. "Synchronization includes matching the goals of the interdependent parts and linking their priorities with other parts of the organization. When conditions change, synchronization realigns the multiple priorities and reallocates resources." Supply chain management—with its emphasis on product, process, customers, and synchronization of all parties' activities—can transform Air Force logistics, specifically spares management.

The Air Force Spares Campaign was born of the need to change fundamentally the way the Air Force manages its spares and the parts used to repair them.

Notes

1. National Research Council, *Surviving Supply Chain Integration*, Washington DC: National Academy Press, 22.

Brigadier General Robert E. Mansfield, Jr

Generally speaking, inventory management involves three primary functions: forecasting, leveling, and ordering.

Reparability Forecast Model

RFM has been in use for more than 5 years, having originally been developed by CACI and used by the San Antonio Air Logistics Center.

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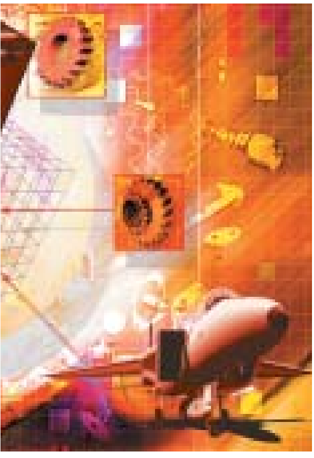
With hundreds of logistics systems in use in the Air Force, it is hard to keep them all straight, much less know where they fit into the big picture. As users of these systems, it is important that logisticians understand, at least at the top level, what they do. Perhaps more important, they should understand what these systems do. Unfortunately, this information is not usually openly shared by the developers, leaving most of us to wonder what is going on inside the *black box*. In an earlier article in this publication, the systems that have played a role in the management of depot consumables were discussed.[1] This article delves deeper into one of the newest of those systems, the Reparability Forecast Model (RFM).

RFM has been in use for more than 5 years, having originally been developed by CACI and used by the San Antonio Air Logistics Center (ALC).[2] Now that it has been included in Air Force Materiel Command's (AFMC) standard suite of systems, a comprehensive understanding of both the purpose and logic of the system is needed to ensure its proper use (and avoid its misuse). This article should help users in that understanding. Although RFM's specific role in Air Force depots is uncertain because of the potential transfer of



Forecasts are used to establish levels, and levels are then used to trigger orders.

the forecasting function to the Defense Logistics Agency (DLA), its logic must, nevertheless, be understood should it continue to play a role in forecasting at any level.[3]

Before discussing the detailed logic of RFM, it is first helpful, from a macroview, to look at the big picture to understand the role it plays in depot materiel management (Figure 1). Generally speaking, inventory management involves three primary functions: forecasting, leveling, and ordering. Forecasts are used to establish levels, and levels are then used to trigger orders.[4] Some systems perform all three functions, while others perform only one or two. For example, with depot consumables, the Wholesale and Retail Receiving and Shipping Program (D035K) has historically used past demands as a forecast of future demands and the economic order quantity (EOQ) model to establish levels and place orders.[5] RFM, on the other hand, is strictly a forecasting system. It uses materiel requirements planning (MRP) logic to translate the planned repair requirements in the Secondary Item Requirements System [D200A (replacement for the D041 Recoverable Consumption Item Requirements System)] into a forecast of consumable requirements. In doing so, it identifies potential shortfalls and allows materiel managers to create special requisitions to avoid associated repair delays. It is important to understand two points about RFM. First, it is a system that operates outside the *core process* and provides an external check of the core process, using a different methodology. Second, as its name implies, RFM is primarily a forecasting tool. Although the forecasts can be used to generate special requisitions, its primary purpose is that of forecasting. It does not calculate levels, and it does not generate routine orders to DLA like the Item Manager Wholesale Requisition Process System (D035A).

The remainder of the article provides more details on how RFM performs this function. This includes a detailed look at the system logic of RFM in the context of materiel requirements planning, after which RFM is modeled. Once the logical foundation is established, RFM and MRP are compared and contrasted in section 3. This discussion focuses on a few of the most significant similarities and differences, as well as the intended uses of RFM. The final section discusses managerial implications of the purpose and logic of RFM to aid depot materiel managers in its proper use. It also helps illuminate some common pitfalls that might be encountered.

RFM System Logic

Background

Motivated by production delays, the San Antonio ALC contracted with CACI to develop RFM in an effort to identify those parts that would hold up production in the future. RFM was subsequently implemented at Oklahoma City ALC and later chosen by AFMC for inclusion in its standard suite of ALC systems. It has since been implemented at all the air logistics centers, albeit in a limited capacity.

As with any computer system, RFM has an internal logic that defines its strengths and weaknesses. In this case, that basic logic is borrowed from MRP systems. To understand how RFM works, materiel requirements planning is discussed. Throughout the discussion, a simple illustrative example of a company that builds chairs is used. Each chair is comprised of three parts: a back assembly, a seat, and four legs. Although the example is purposely kept simple, the conclusions apply, by extension, to more complex systems as well. In fact, the example is well-suited to the discussion of differences between RFM and MRP, while avoiding an unnecessary level of detail.

Materiel Requirements Planning

MRP systems have three primary inputs: the master production schedule (MPS), the bill of materials (BOM), and inventory records.[6] The master production schedule is comprised of the scheduled end-item production requirements, by date, for each item. An example for the chair is shown in Table 1.

The BOM is a database containing the hierarchy of parts in an assembly. For the chair example, the BOM is presented schematically in Table 2.

The third input, or set of inputs, is inventory records. This is where the MRP system gets data on current inventory levels and projected due-ins, as well as lead times. Together with the master production schedule and BOM, the inventory records allow the MRP system to calculate how much of each part to order and when to order

The goal of materiel requirements planning is to schedule component orders (that is, the back, seat, and legs) so that the parts are all available for final assembly in time for the end product (the chair) to be assembled before the due date.

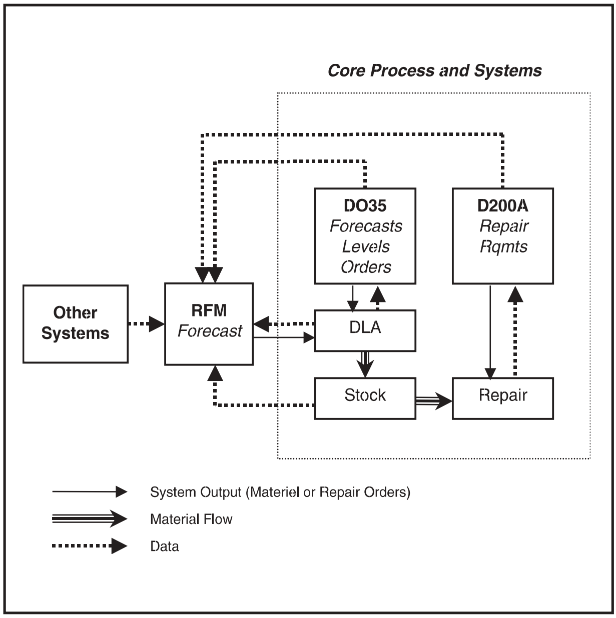


Figure 1. The Reparability Forecast Model and Its Role in Depot-Consumable Management

Week	1	2	3	4	5	6	7	8	9	10	11	12
Forecasted Chair Rqmts	5	8	12	5	7	10	9	8	3	10	12	6

Table 1. Master Production Schedule for Chair Example

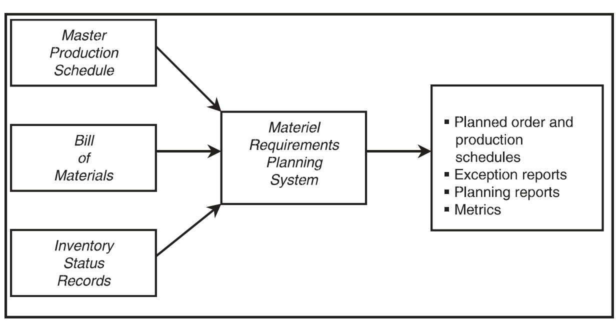


Figure 2: Inputs and Outputs of an MRP System

it to meet the MPS requirements. Figure 2 illustrates the basic inputs and outputs of an MRP system.[7]

The goal of materiel requirements planning is to schedule component orders (that is, the back, seat, and legs) so that the parts are all available for final assembly in time for the end product (the chair) to be assembled before the due date. In technical terms, a lead-time *offset* is applied to the end item and all its components. For the example, the final assembly of the chair takes 1 week; therefore, it is started 1 week prior to the due date. All three components are then scheduled to arrive just prior to the start of final assembly. To accomplish this, they must be ordered to accommodate their various lead times. In this case, the legs and seat must be ordered 1 week prior to final assembly (lead time = 1 week) and the back 2 weeks prior (lead time = 2 weeks). In this way, all components arrive when needed for final assembly, and the due date is met. This process is illustrated in Figure 3.

The primary output of the MRP process is the materials plan, which is simply a time-phased schedule of order releases for each component needed in the end item. Table 3 presents a materials plan for the chair example and shows the lead-time offsets for the various components with shading.[8]

The primary output of the MRP process is the materials plan, which is simply a time-phased schedule of order releases for each component needed in the end item.

MRP Versus RFM: Similarities and Differences

Now that the foundation has been laid, the discussion can turn to the subject of interest: the RFM. In the following

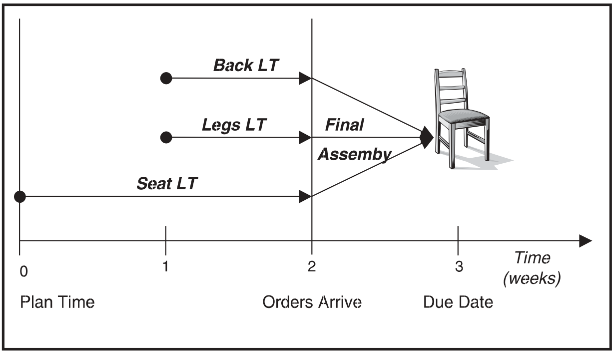


Figure 3: Time-Phased Diagram of Chair Assembly

Although there are some important differences between RFM and MRP, they share two major traits: system logic and structure.

Part No	Noun	BOM Level[1]	Next Higher Assembly[2]	Quantity Per Assembly[3]	Lead Time (weeks)
1	Chair	0	-	-	1
2	Leg	1	Chair	4	1
3	Back	1	Chair	1	2
4	Seat	1	Chair	1	1

1. By convention, the end item is generally assigned as level 0, while the direct components making up the end item are assigned as level 1. Parts making up level 1 components would be assigned level 2 and so on. In the Air Force, an end item would be level 0, followed by level 1-line replaceable units, followed by level 2 shop replaceable units, followed by lower level parts.
2. The next higher assembly is simply the next higher assembly in which the part is consumed.
3. The quantity per assembly refers to the quantity of the part in the next higher assembly.

Table 2. Bill of Materials (Quantity Per Unit Shown in Parentheses)

discussion, MRP conventions laid out thus far are used to identify similarities and differences between MRP and RFM. Additionally, important differences are noted between a *traditional* manufacturing environment and that of repair, which has significant implications in terms of system performance.

Similarities

Although there are some important differences between RFM and MRP, they share two major traits: system logic and structure.

Similarity 1: System Logic. MRP systems, as previously discussed, apply a lead-time offset to all components required for production of an end item. This allows the system to automatically order the components at the right times so they all come together for final assembly. Likewise, RFM applies lead-time offsets to all consumable items required for projected end-item repairs, allowing the system to calculate the specific consumable requirements. By comparing those requirements with the items in stock and on order, a report of estimated shortfalls can be generated. Note the distinction between MRP's automatic ordering and RFM's report. This distinction will be discussed in more detail later, but for now, it is important to understand that the underlying system logic is identical.

Similarity 2: System Structure. Recall from Figure 2 the inputs and outputs of a typical MRP system. RFM follows exactly the same structure, but different system names and terminology apply. Figure 4 reproduces Figure 2, with the RFM elements in bold and the corresponding MRP elements in parentheses.[9]

RFM applies lead-time offsets to all consumable items required for projected end-item repairs, allowing the system to calculate the specific consumable requirements.

Week	1	2	3	4	5	6
Chair (End Item, Assembly 1 week*)*						
Net Requirements	5	8	12	5	7	10
			Lead Time			
Planned Order Releases	8	12	5	7	10	
Legs (Qty 4, Lead Time 1 week*)*						
Net Requirements	32	48	20	28	40	
		Lead Time				
Planned Order Releases	48	20	28	40		
Seat (Qty 1, Lead Time 2 weeks)						
Net Requirements	8	12	**5**	7	10	
		Lead Time				
Planned Order Releases	**5**	7	10			
Back (Qty 1, Lead Time 1 week)						
Net Requirements	8	12	**5**	7	10	
		Lead Time				
Planned Order Releases	12	5	7	10		

Table 3. MRP Materials Plan for Chair Example

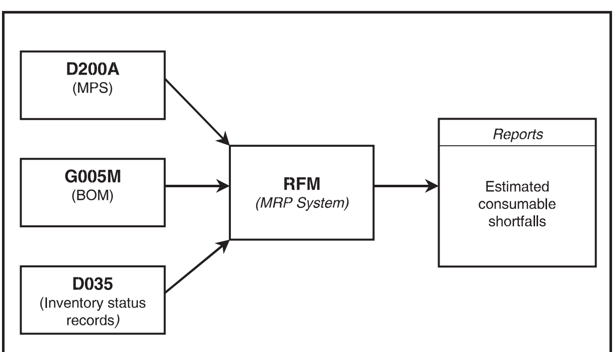


Figure 4: Inputs and Outputs of RFM (MRP Equivalents from Figure 2 Shown in Parentheses)

Although the overall logic and structure of RFM and MRP are equivalent, there are many differences.

The BOM inputs in Figure 2 come primarily from the Depot Maintenance Materiel Support System (G005M). These include production numbers, quantity per next higher assembly, and replacement percentages, among others.[10] The replacement percentage is an important distinction in a repair environment in that it is an average and will be discussed in more detail as a difference between MRP and RFM.

The MPS inputs come in the form of repair requirements from D200A*. In this case, the MPS and repair requirements are essentially the same from the standpoint of MRP logic. In other words, there is little difference between end-item demand in manufacturing and repair requirements in depot maintenance *from the perspective of the system*. Finally, the inventory data come from a collection of systems, including the D035A, D035K, the Logistics Management Data Bank (D062), Acquisition and Due-In System (J041), DLA systems, and others.[11] As in an MRP system, the inventory data tell RFM how many there are, how many are due in, and when they are due in, in addition to general indicative data. In all, about a dozen systems provide inputs to RFM for processing.

Differences

Although the overall logic and structure of RFM and MRP are equivalent, there are many differences. The three most important to materiel managers, in terms of system performance, are discussed.

Difference 1: Dependent, Semidependent, and Independent Demand. In a traditional manufacturing environment, the quantity of parts required to produce each end item is known. This is referred to as *dependent demand*, since the demands for parts are directly dependent on the demands for the final assembly or product. MRP systems are designed for such environments and are classified as *dependent demand inventory systems*. In repair, however, the quantity required in most cases is unknown until the end item is disassembled, inspected, and tested.

Although the demand for some parts in repair is certainly directly dependent on the number of end items repaired, almost all can be considered as semidependent or as indirect materiel. Semidependent items are those where the number required for each repair actually varies, although the overall demands over time tend to correlate to end-item repairs. This presents a problem since RFM needs to have a hard quantity to use in the calculation of requirements. This hard quantity comes in the form of a replacement factor. Indirect materiel, by contrast to the first two, experiences independent demand. Such items are typically low-cost, high-demand items that are carried in a bench stock or similar convenient storage area. They also are ordered usually in larger batches, making exact demands difficult to correlate to end-item repairs. Indirect materiel does not lend itself to MRP logic and is better dealt with using *independent demand inventory systems* like EOQ. Obviously, the more dependent the demand, the more appropriate the use of RFM as a forecasting tool.

Although the demand for some parts in repair is certainly directly dependent on the number of end items repaired, almost all can be considered as semidependent or as indirect materiel.

Difference 2: The Floating Bill of Materials. The most common solution to the problem of unknown requirements (and the one used in RFM) is the use of a replacement factor, which is calculated using historical data.[12] The calculation is simply the number of component issues over a period of time divided by the number of end-item repairs during that same period, which provides a rough estimate of the percentage of time each part is replaced during a repair action. If 1,000 chairs have been repaired over the last year, for example, only 100 seats, 300 back assemblies, and 1,000 legs might have been used. The associated replacement factors would, therefore, be 0.1, 0.3 and 0.25, respectively.[13] The RFM forecast for the next ten chairs, therefore, would be one seat, three back assemblies, and ten legs. Unfortunately, this will almost definitely be wrong, leading to the traditional good news and bad news.

First, the good news: some simple statistics, specifically the Law of Large Numbers, can help us deal with this problem. The law states that a sample mean of size *n* converges to the true mean as *n* gets large, or mathematically:[14]

$$P(M_n \rightarrow \mu, n \rightarrow \infty) = 1$$

In the context of RFM, the M_n represents the average of the actual requirements (*M*) for *n* repairs, while *m*

What this means to RFM users is that, even though forecasted consumable requirements for individual repairs can be expected to be wrong (that is, M_n ? m)*, the more requirements are pooled, the closer they will be (as* n *gets larger,* M *approaches* m*).*

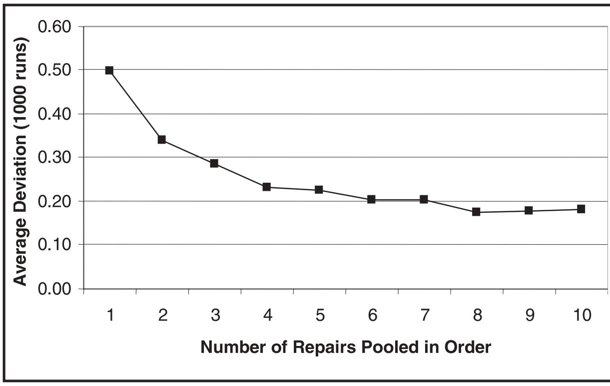


Figure 5. Results of Illustrative Simulation (1,000 Runs, Demands U~(1,10), Orders Based on RFM Calculation Using Replacement Factor of 5)

represents the replacement factor. If the assumption is made that the past demands used in the replacement factor are an accurate predictor of the future, then *m* is also the future average demand rate per repair. What this means to RFM users is that, even though forecasted consumable requirements for individual repairs can be expected to be wrong (that is, M_n *? m)*, the more requirements are pooled, the closer it will be (as *n* gets larger, *M* approaches *m*). In other words, RFM assessments can be used to identify shortfalls, but orders should be made in larger lot sizes to smooth out the variability in individual repairs. Forecasting consumables for ten repairs will be more accurate than forecasting for a single repair.

This fact can be easily demonstrated by simulation. Figure 5 shows the results of a simple simulation of 1,000 runs, for an item with a quantity per assembly of ten and a replacement factor of five.[15] Using RFM logic, a quantity of five is, therefore, forecasted for each repair. The horizontal axis in Figure 5 represents the number of repairs, from one to ten, that are *pooled* in a single order. Even ordering for two repairs significantly reduces the resulting deviation from actual requirements, over ordering for a single repair, from 50 to 34 percent. Pooling just four repairs cuts the expected deviation in half. Note also the diminishing returns, suggesting the gains level off beyond some point.

The results of this simple illustrative simulation are consistent with those of a more rigorous simulation of depot engine repair completed in 1998.[16] Ordering for individual repairs led to a modest increase in materiel availability at an extremely high cost in excess inventory. In contrast, ordering the EOQ whenever a shortfall was identified significantly increased materiel availability with a modest increase in inventory.

Now for the bad news: this is precisely the opposite of the current AFMC policy of placing smaller, more frequent orders. So the practice of batching orders must be used with discretion and only for those items that will hold up production. Ideally, the quantity ordered based on RFM forecasts would correspond to the point at which the gains level off. Alternatively, a second potential solution exists in the form of a *modified replacement factor*.

Ordering the EOQ whenever a shortfall was identified significantly increased materiel availability with a modest increase in inventory. Now for the bad news: this is precisely the opposite of the current AFMC policy of placing smaller, more frequent orders.

Recall that the replacement factor is an average, meaning that it will be insufficient about 50 percent of the time. It is a simple matter to incorporate service levels into the calculation of the replacement factor, ensuring that parts are on hand with an acceptable probability. This is the equivalent of adding a safety stock level to the replacement factor. For example, if the chair back has a replacement factor of 0.3, three would be needed, on average, for every ten chairs to be repaired. Ordering three for every ten repairs would give a service level of approximately 50 percent, meaning that three would only be enough about half of the time. If, however, 95 percent of the time, five or less are needed, five for every ten to be repaired could be ordered with assurance that there would be enough back assemblies in almost all cases.[17] Using such a *modified replacement factor* is one way to avoid pooling large numbers of requirements for ordering.

Difference 3: The Role of the System. On the output side of Figures 2 and 5, there is another distinction between MRP and RFM. Where materiel requirements planning is a complete production and inventory system (particularly modern MRP and MRP II systems, which consider capacity constraints as well as inventory), RFM is an inventory-only, *decision support system*. MRP actually plans the production and places orders, while RFM simply flags

RFM is a decision support system, meaning it is not the core system that sets levels and orders parts. It is used to create forecasts of consumable demands, which can then be used to generate special requisitions if deemed necessary by materiel managers.

items that may hold up planned production based on a forecast. The logic is the same, but the purpose and outputs are different.

RFM can provide two types of forecasts for materiel managers:[18]

- An estimate of inventory availability, given the current projection of repairs in D200A
- An estimate of shortfalls if the current projection changes (a *what if* analysis)

In either case, materiel managers can generate special requisitions and expedite existing requisitions to meet consumable demands for repairs. These special requisitions are generated automatically by RFM but are subject to review by depot materiel managers before their release to DLA. They can also use the forecast to justify make-or-buy decisions or adjust the production schedule based on materiel availability.[19]

Conclusions and Management Implications

Up to this point, it has been established that RFM is a forecasting system that uses MRP logic, and MRP has been discussed. In the last section, some major similarities and differences between the two were identified. This is concluded with a list of suggestions for users, all based on the preceding discussions. Table 4 summarizes the problems and proposed solutions.

What RFM Is and What RFM Is Not

RFM is a decision support system, meaning it is not the core system that sets levels and orders parts. It is used to create forecasts of consumable demands, which can then be used to generate special requisitions if deemed necessary by materiel managers. It is intended to give materiel managers at the depots the capability to assess parts availability to support current repair projections and conduct *what if* analyses of upcoming changes in the repair projections. Unlike MRP systems, it is not intended to routinely determine parts requirements and automatically place orders.

Dependent Demand

MRP and RFM are designed for items with dependent demand. For items with at least semidependent demand, a floating BOM (replacement factors) can be used, albeit with a full understanding of its implications. For items with independent demand, such as indirect materiel, RFM should not be used to forecast demand.

Two additional item characteristics should also be considered in addition to the dependence issue. First, end items with a fairly constant repair schedule over time will derive little benefit from the use of RFM. Recall that the EOQ model assumes constant, steady demand. If this is the case, RFM will do little to improve existing levels. Second, for consumables that are common to many end items, the variability in repair schedules for each will tend to balance out in aggregate. This will usually mean less variability

RFM is intended to give materiel managers at the depots the capability to assess parts availability to support current repair projections and conduct what if analyses of upcoming changes in the repair projections. Unlike MRP systems, it is not intended to routinely determine parts requirements and automatically place orders.

Problem	Solution
Parts with semidependent demand	*Floating* Bill of Materials.[1]
Parts with independent demand (indirect materiel)	Exclude from RFM forecasts.
Floating BOM quantities	• Larger orders.[2] • Modified replacement factors.[3]
Parts with constant demand	None. RFM probably will not help, but it will not hurt either. If demand is constant, existing levels should suffice in most cases.
Misdirected metrics	Metrics should focus on forecast accuracy.
Poor coordination	Maintain close coordination. If DLA loses confidence in RFM-initiated forecasts, it will be hesitant to continue honoring them.
Overuse	Use RFM discriminately for only those items that show dependent demand characteristics and are consistently short due to insufficient levels.

1. Floating BOM is also a problem (see Floating BOM quantities, row 3 of table).
2. Larger orders are inconsistent with AFMC policy of daily ordering.
3. Modified replacement factors require more detailed data than currently available.

Table 4. RFM Problems and Recommended Solutions

Metrics need to be carefully developed, measured, and analyzed to determine if RFM is meeting Air Force needs without an unreasonably high inventory investment.

in consumable demand and, therefore, less benefit from RFM assessments. Users should screen their consumables accordingly rather than using RFM indiscriminately across all items.

Caution: Floating BOM Ahead

Earlier, the issue of the *floating BOM*, which means that the actual quantities used vary from repair to repair, was discussed. Because the replacement factor in the BOM is an average, RFM's forecasts will be either too high or too low almost all the time. Unfortunately, it is not known in advance which. Because MRP logic was not intended for a repair environment with unknown part requirements, extreme care should be exercised in using the output of RFM. Although it can be a useful tool, its output should not be regarded as an exact solution. Materiel managers should balance the need for a large batch order (remember the discussion on the Law of Large Numbers) and the current AFMC policy of daily ordering (which will smooth out the demand that DLA sees). A modified replacement factor incorporating a safety-level quantity is one alternative to batching orders that may avoid unnecessary excess inventory, while maintaining target availability.

Metrics

Metrics need to be carefully developed, measured, and analyzed to determine if RFM is meeting Air Force needs without an unreasonably high inventory investment. Although early metrics were geared toward ensuring that the system was interfacing correctly with Air Force and DLA legacy systems, a more important set of metrics is one that shows whether the RFM forecasts are accurate. To do this, the RFM forecasts, the orders they generate to DLA, and the actual demands that correspond to those forecasts and orders must be tracked. In doing so, an assessment of whether RFM is a valid forecasting tool can be made.

Coordination

Coordination between AFMC and DLA has been exemplary throughout the development and implementation of RFM. This coordination must continue so that both sides openly share information and metrics. Only if DLA has faith in RFM forecasts will it continue to use them for its own planning purposes.

Scope of Use

At present, RFM is being used on a very limited basis, primarily for depot engine repair. Increased use will cause a corresponding rise in special requisitions to DLA, which will lead to an increased workload. It remains to be seen whether or not this increase will cause problems on the DLA end. Again, continued coordination will help avoid future problems regarding workload.

RFM can be a useful tool for forecasting consumable requirements at the depots, but users must be fully aware of the logic of the system to use it properly and avoid its misuse.

RFM's Future Role

The combined effects of the Customer-Oriented Leveling Technique (COLT)[20] and daily ordering at the air logistics centers should, in the near future, improve consumable item support to depot repair operations.[21] This, in turn, should reduce the dependence on external w*atchdog* forecasts such as those generated by RFM. That said, the *what if* capability of RFM still can prove useful to materiel managers in adjusting to known demand changes. The forecast methodology of RFM can also be incorporated into existing or future leveling and ordering systems, although the cautions set forth in this article will still apply in that case.

RFM can be a useful tool for forecasting consumable requirements at the depots, but users must be fully aware of the logic of the system to use it properly and avoid its misuse.

Notes

1. Maj Kevin Gaudette, Dr Douglas Blazer, and H. Kenneth Alcorn, "Managing Air Force Depot Consumables, *Logistics Dimensions 2003*, Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama, Dec 02, 22.
2. "Reparability Forecast Model Background Paper," CACI, Aug 96.
3. One of the authors has been directly involved with Air Staff discussions on transferring the forecasting function to DLA. If DLA takes on the function, an option that has been discussed is that of using either RFM or a system like it to perform this function.
4. This is somewhat simplified for the sake of this article. Forecasts play a role in determining stock levels, whether the forecast is based on past demand or on some anticipated future demand. Orders are then placed periodically to keep physical stock close to the stock levels, with order size being largely a matter of policy. Other factors involved in the forecasting, leveling, and ordering functions include leveling technique, cost structure, service-level targets, and policy.

5. The EOQ leveling function in the D035A will be replaced gradually by COLT, and its ordering function has been replaced by daily orders in lieu of ordering the EOQ when stock reaches the reorder point.
6. Richard B. Chase and Nicholas J. Aquilano, *Production and Operations Management,* 6th ed, Burr Ridge, Illinois: Irwin, 1992, 704.
7. *Ibid*.
8. The materials plan presented here omits some elements for clarity. A real materials plan would include starting balances and scheduled receipts, which would be taken into account in determining the net requirements.
9. Adapted for RFM, original MRP version from Chase and Aquilano, 704.
10. *RFM Users Manual*. CACI, Jul 97.
11. *Ibid*.
12. *RFM Users Manual*. RFM uses three different types of calculations for the replacement factor. The first is 8 quarters of consumable demands divided by 8 quarters of end-item production. The second, similar to the first, uses only 4 quarters of data. The final method uses the replacement percentage in the G005M and multiplies it by the units per assembly.
13. [100 seats]/[1,000 chairs repaired X 1 per assembly] = 0.1
    [300 backs]/[1,000 chairs repaired X 1 per assembly] = 0.3
    [1,000 legs]/[1,000 chairs repaired X 4 per assembly] = 0.25
14. The mathematical expression here is actually the *strong* Law of Large Numbers, which says that the sample mean approaches the population mean with a probability of one. There is also a *weak* Law of Large Numbers, which says the same thing but with a less rigorous mathematical foundation. More detail can be found in almost all statistics books.
15. The underlying data are omitted for brevity but are available from the corresponding author upon request.
16. Kevin Gaudette, "Materiel Requirements Planning in Air Force Depot-Level Maintenance," master's thesis, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, Sep 98.
17. This recommendation requires more detailed data collection than is generally available. Consumable usage data need to be generated at the shop level to calculate the actual variability in demand.
18. *RFM Users Manual*
19. "Reparability Forecast Model Background Paper."
20. See Don Kringen and Jason Vinson, "Customer-Oriented Leveling Technique," AFMC Briefing, Wright-Patterson AFB, Ohio, 9 Oct 01, for estimates of supportability improvements using COLT.
21. See Capt Buddy Berry, Capt Brad Anderson, Dr Douglas Blazer, John Dietz, and 1st Lt Severine Colborg, "Harmonization of Air Force and Defense Logistics Agency Economic Order Quantity Policies," Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama, Oct 98, for estimates of results using daily ordering.

How USAFE Is Applying Operation Allied Force Lessons Learned

As a result of lessons learned during Operation Allied Force, the United States Air Forces in Europe (USAFE) Munitions Directorate created the Theater Munitions Distribution System (TMDS) to create flexibility for munitions distribution by establishing regional munitions hubs in the north, central, and southern regions of the USAFE area of responsibility (AOR). The hubs were chosen because they had the requisite storage, maintenance, and transportation capabilities of the remaining USAFE bases necessary to stage, repair, and swing munitions to any fight worldwide. The hubs are RAF Welford, United Kingdom; Ramstein Air Base, Germany; and Camp Darby, Italy. The existing munitions infrastructure and storage capabilities at RAF Welford, along with the outstanding civil trucking and seaport capabilities in Great Britain, make it an ideal location. Ramstein directly supports European operations and provides worldwide support through its airlift capability. Its railhead and truck outload points improve the ability of the United States to stage and move ammunition to and from explosives-sited seaports.

Camp Darby helps support munitions supply for all combat operations south of the Alps. More than half the munitions dropped in Operation Allied Force were shipped from there.[63] It gives the United States tremendous munitions throughput capability and is the only munitions storage area in the entire European AOR with both an explosives-sited water dock and railhead located adjacent to the munitions storage area. The only other US munitions storage area with an explosives-sited seaport adjacent to it is at Kadena Air Base, Japan.

The munitions infrastructure planned under TMDS directly supports joint movement of munitions. The US Army, Europe would benefit directly from Ramstein and Camp Darby for its mission to project land power through the planned storage, staging, and transportation infrastructure. Likewise, Naval Forces, Europe can take advantage of all munitions hub port improvements to facilitate seapower. The North Atlantic Treaty Organization coalition forces can enjoy the same benefits as US forces for munitions movements through efficient implementation of foreign military sales.

Finally, TMDS helps minimize host-nation challenges. By regionally positioning munitions, the number of country clearance activities during coalition warfare can be minimized. This also provides an opportunity to establish modes for munitions transport, enabling US forces to fully inform sovereign nations of planned munitions movements; allows concerns to be voiced prior to potential conflicts; and permits the US European Command to mitigate national concerns before they become serious. TMDS establishes the means and methods to ensure the success of coalition warfare.[1]

Notes

1. Maj Dane West, "Munitions Support for Coalition Warfare," USAFE/LGW, 23 Jul 01.

Major Kirk L. Kehrley, USAF

With most organizations spending at least one-third of their overall budgets on purchasing goods and services, procurement holds significant business value.

E-Procurement and the US Military

E-procurement is one of many new terms that have emerged in the business vocabulary since the mid-1990s. Other common terms today surrounding business applications of the Internet and World Wide Web include e-business and e-commerce.

Major David M. Doe, USAF

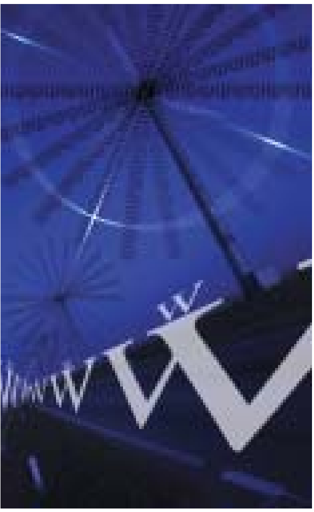
Introduction

> *Today, we are on the verge of another revolution. Inventions like the computer, fiber-optic cable, and the Internet are changing the way we work, learn, and communicate with each other.*
>
> **—President William J. Clinton**[1]

The Internet is revolutionizing the way in which business is conducted around the world. In the mid-1990s, the Internet was simply viewed as an alternative channel for buying and selling goods and services. Now companies realize that much of their businesses should be focused around this open and flexible network. In just a few short years, electronic business or *e-business* has effectively redefined the standards of performance, speed, and price in an increasingly global marketplace. Although once only connected with *dot com* firms, e-business could have a greater impact on the large, established corporations of the world.

One of the ways in which business is changing around the Internet that has particular relevance to the US military is in the area of procurement. Procurement has been defined as:

> …all of the activities involved in obtaining material and services and managing their inflow into an organization toward the end user. It includes obtaining manufacturing supplies for an assembly line, as well as obtaining paper and pencils for a bank.[2]



In both the private and public sector, the procurement process has traditionally consisted of endless paperwork and layers of bureaucracy.

With most organizations spending at least one-third of their overall budgets on purchasing goods and services, procurement holds significant business value.[3] To reduce costs and improve efficiency in their supply chains, companies, ranging from IBM to General Electric to Ford, have turned to Internet-enabled tools and processes known as electronic procurement or *e-procurement*.

Transformation in the Department of Defense

Within the Department of Defense (DoD) today, transformation is the new buzzword, and this concept includes not only weapons and warfighters but also the processes by which goods and services are procured. In fact, on 10 September 2001, Secretary of Defense Donald Rumsfeld, in a keynote address at the DoD Acquisition and Logistics Excellence Week, stated:

> Just as we must transform America's military capability to meet changing threats, we must transform the way the Department works and what it works on. We must build a Department where each of the dedicated people here can apply their immense talents to defend America, where they have the resources, information and freedom to perform. Our challenge is to transform not just the way we deter and defend, but the way we conduct our daily business.[4]

Within the Department of Defense today, transformation is the new buzzword, and this concept includes not only weapons and warfighters but also the processes by which goods and services are procured.

Much of Rumsfeld's emphasis on transformation in acquisition processes is derived from the concept of the revolution in business affairs, which calls for large-scale changes in the way in which procurement and other business practices are conducted in the Defense Department. In June 1997, Secretary of Defense William Cohen called for a revolution in military affairs, which he believed must be accompanied by this revolution in business affairs.[5]

What is E-Procurement?

E-procurement is one of many new terms that have emerged in the business vocabulary since the mid-1990s.

Other common terms today surrounding business applications of the Internet and World Wide Web include e-business and e-commerce. E-business represents a combination of technologies, business models, and managerial techniques that can enable fundamental process innovation within a firm. Meanwhile, e-commerce is a subset of e-business and is focused on the revenue-generating aspects of the firm.[6] Generally, e-procurement is considered a subset of the larger effort by a firm to become an e-business and is particularly focused on the way companies manage their supply chains.

Types of E-Procurement

Currently, e-procurement consists of multiple electronic aspects, including catalogs, bidding, English auctions, reverse auctions, market exchanges, and end-to-end procurement processes. Explanations of each are provided below.

- *Electronic or e-catalogs* are simply custom catalogs that suppliers establish on the Internet.[7] An example of an electronic catalog would be a Web interface used by companies to order office supplies from a common negotiated price list. Prices for each company are likely to be lower because they are based on the annual volume purchased by the entire company. In addition, payments for companies ordering from e-catalogs can be consolidated automatically; expense statistics can be monitored and budgeted easily; and paperwork, on the whole, is minimized.[8] In 1995, the General Services Administration (GSA) established *GSAAdvantage!* which is an e-catalog for federal government organizations to use for procuring goods. With *GSAAdvantage!* federal employees can go online and order more than a million GSA stock items from the federal supply system.[9]
- *Electronic bidding* consists of a request for a quote that is sent electronically by a company to different suppliers and then is received and evaluated electronically.[10] An example of bidding would be an aircraft corporation sending electronic requests for quotes to multiple tire suppliers to find the best quality and price for a type of tire. With electronic bidding, paper contracts and associated documents for transactions are eliminated, and the entire procurement is completed much quicker than if it were done through the mail or person to person. In 2001, GSA added electronic bidding, which is called *e-buy*, to *GSAAdvantage!* With e-buy, federal buyers can post requests for proposals for

Electronic bidding *consists of a request for a quote that is sent electronically by a company to different suppliers and then is received and evaluated electronically.*

specific services, and contractors are notified of those opportunities in e-mails. Contractors can then offer quotes over the *e-Buy* Web site that is embedded in *GSAAdvantage!*[11]

- An *electronic English auction* is an Internet version of the well-known type of auction that is initiated by one seller where the price rises during the auction. The final price is dependent on the bids of other buyers, and the last bid is known to all of the buyers.[12] By accessing a Web site, buyers can check the current spot prices of a variety of items to determine whether to purchase or wait for the prices to become more favorable.
- In an electronic *reverse auction*, a buyer initiates the auction by specifying the demand and specifications in a request for quote. During the online, real-time auction, suppliers are able to submit price quotes and view the quotes of competitors. With a time limit placed on the auction, suppliers then submit price quotes and are able to view the other quotes submitted. As opposed to English auctions, the price drops during the auction, with the last bid being known to all the bidders. In some cases, multiple buyers may aggregate their purchasing power to get deeper discounts on the total quantity of any one purchaser. Reverse auctions are most useful for commodity-type procurements in which there are clear and well-defined specifications from the

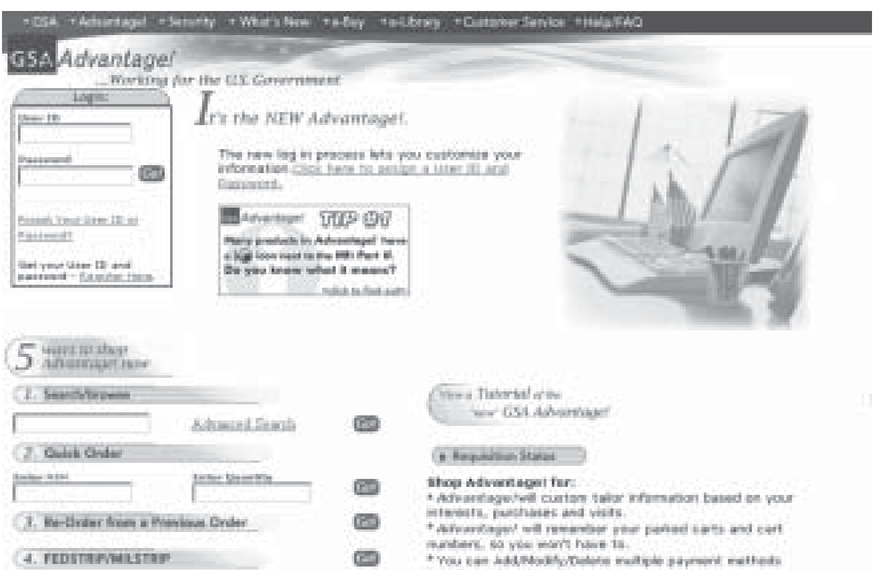


Figure 1. *GSAAdvantage!* Web Site (www.gsaadvantage.gov)

buyer. Entire companies, such as FreeMarkets and TradeOut, are dedicated to creating electronic reverse auction sites, as well as other e-procurement tools for firms without the internal capabilities to do it themselves.

- A *market exchange* is an electronic marketplace where multiple buyers and sellers can get together and exchange goods at spot prices. Also called *business to business (B2B)* or *electronic hubs*, market exchanges have become popular among the largest Fortune 500 firms in the last couple of years. For example, in March 2000, Boeing, Lockheed Martin, BAE Systems, and Raytheon established a B2B exchange called *Exostar* with the hope of cutting transaction expenses, aggregating buying power, and exploiting the efficiencies of a single marketplace.[13] Together, the four companies do $71B of business each year with 37,000 suppliers and hope to save billions of dollars through the exchange.[14] In April 2000, Ford, General Motors, and Daimler Chrysler followed suit by creating their own online auto-supplier network called *Covisint* that processes more than $240B in annual spending.[15]
- Finally, *end-to-end (ETE) procurement systems* are contracting systems that integrate and share data from numerous independent contracting and financial systems. Unlike the five aspects of e-procurement discussed above, ETE is a system internal to an organization that provides a seamless exchange of data from systems that had limited ability to *communicate* in the past. Many ETE systems have the capability to interact with e-catalogs and perform auctions.

A market exchange is an electronic marketplace where multiple buyers and sellers can get together and exchange goods at spot prices. Also called business to business or electronic hubs, market exchanges have become popular among the largest Fortune 500 firms in the last couple of years.

ETE systems are particularly attractive to the Defense Department because they electronically store that which is usually saved on paper, such as purchase orders, supplier acknowledgments, shipping and receiving documents, invoices, accounts payable vouchers, supplier payments, and account reconciliation reports. In addition, ETE provides a single point of entry for contracting, finance, and other procurement officials. These personnel no longer have to rekey data, which can lead to numerous errors, because information is passed from system to system. Instead, the ETE system links all these systems and databases and shares the data.[16]

The Advantages of E-Procurement

According to Booz-Allen & Hamilton, a large US consulting firm, the advantages of e-procurement fall in three areas: “streamlined processes, reduced costs, and the

ETE is a system internal to an organization that provides a seamless exchange of data from systems that had limited ability to communicate *in the past.*

opening of new business opportunities."[17] First, e-procurement streamlines processes because of simpler and faster ordering, reduced paperwork, easy online comparison, fewer human errors, and lower inventory costs. Second, cost reductions are possible because comparisons can be made easily and buys can be aggregated across an enterprise. In the private sector, annual cost savings from e-procurement generally range from 25 to 50 percent.[18] Finally, new business opportunities, which are of more concern to the private sector than the public, arise because of access to new customers from the information that is generated from the transactions.[19]

The simple example of a company's procuring office supplies from an electronic catalog highlights some of the advantages of e-procurement. If a company is composed of different departments or plants, possibly in different locations across the country or around the world, each may buy office supplies from different suppliers, unaware of the

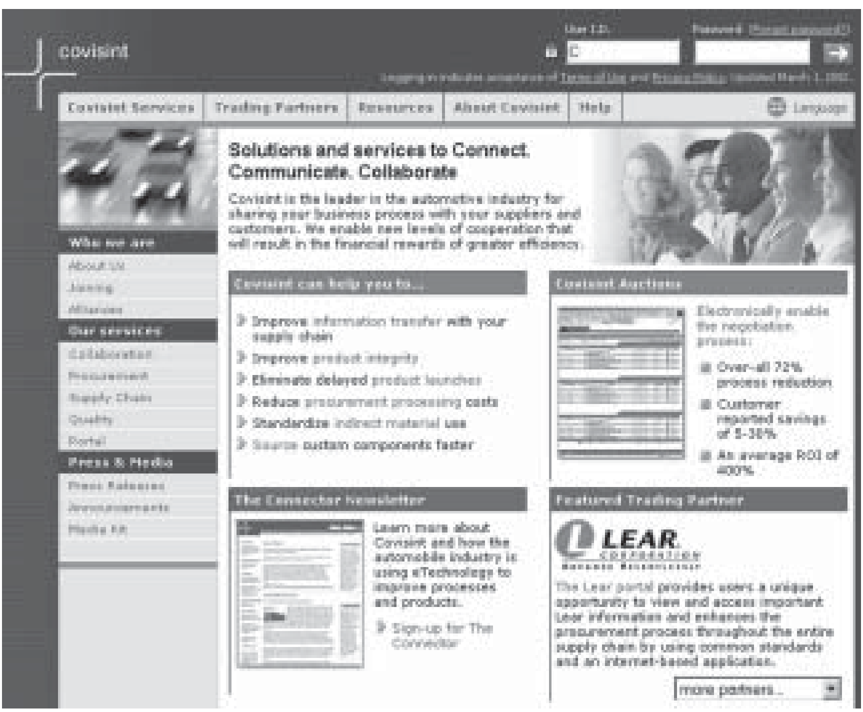


Figure 2. ***Covisint Automobile Market Exchange*** **Web Site (www.covisint.com)**

other's actions. As a result, prices may vary based on the individual negotiating abilities of personnel and the differing volume that is purchased in each department. In addition, order processing is usually done manually with phone calls and faxes, management approval may be required for each transaction, and separate payments may need to be generated for each requisition.

With an e-catalog, the purchases can be aggregated across the company, and discounted prices are available based on the volume of the purchases. In addition, a company can make a single payment for the goods and easily track all of its transactions. The Air Force Materiel Command (AFMC) is hoping to reap these types of benefits with its *E-Purchase* Web site. With E-purchase, AFMC employees can order a variety of supplies for their organization with the Government Purchasing Card (GPC).[20]

Another significant benefit of e-procurement is the *pushing* of the purchasing of goods and services down to the end users. As a result, the size of the procurement function within companies will likely decrease over time because individual employees can acquire the goods and services they need for their tasks. Because 50 percent of the DoD civilian acquisition workforce is eligible to retire by 2005, smaller procurement organizations should be particularly attractive to the military.[21] In the future, if military contracting and finance tasks are Web-driven, the Defense Department will be able to hire fewer, yet more technologically capable, employees to replace these retiring procurement specialists.

Interestingly, the advantages of e-procurement mentioned above have had a powerful effect not only on small *dot com* firms but also on large, established companies in the United States.[22] Of these large companies, none has been more successful with e-business applications across the spectrum than IBM.

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E-Business at IBM

Our chairman of the board chose e-business to be the most important corporate strategy. It's the focal point of every division of the IBM company: the software, services, and server groups, and the PC business.

—Alfred Spector, General Manager of Marketing and Strategy, IBM[23]

Because 50 percent of the DoD civilian acquisition workforce is eligible to retire by 2005, smaller procurement organizations should be particularly attractive to the military.

Many of America's largest Fortune 500 companies—such as Boeing, General Electric, Ford, and Daimler Chrysler—have adopted e-procurement strategies in the last few years. Arguably, none has been as successful as IBM. Interestingly, prior to embarking on its e-business journey, IBM was remarkably similar to any of the US military departments today, in terms of numbers of employees and organizational structure.

In 1993, IBM began transforming itself into one of the world's first and now most successful e-businesses. Absolute necessity drove IBM to this complete shift in business strategy. Over an 8-year period, beginning in 1985, IBM's market value plunged from $95.7B to $32.8B. From 1991 through 1993, IBM lost $16B, including $8.8B in 1993, which was the largest loss of any corporation in any year in history. [24]

In the early 1990s, IBM was a highly complex corporation with many redundant operations. The firm had 400,000 employees doing business in 160 countries. Within IBM, there were 20 different businesses, each with its own manufacturing, accounting, information technology, and payroll systems.[25] Jamie Hewitt, vice president of E-Business Transformation within IBM's server group, mentioned in an interview that the complexity was difficult for IBM to manage and customers did not know how to interface with the company because there was not a single, integrated IBM with which to deal.[26]

To alleviate the immediate financial crisis, IBM eliminated more than 117,000 jobs, incurred more than $28B in restructuring charges, and consolidated almost 300 different financial systems into fewer than 30. However, more significant, IBM chairman Louis Gerstner recognized that the most important application for the Internet would be business transactions, not simply having the best browser or search engine.[27] As a result, Gerstner chose e-business, which is broader in focus than e-procurement, to be the most important corporate strategy. It became the focal point of every division of the IBM company: software, services, server groups, and the PC business.

IBM reengineered its core business processes about what it now calls the *e-business cycle*. The e-business cycle consists of "leveraging knowledge and information, transforming business processes, building new applications, and running a scalable, available, secure environment."[28] Largely due to the e-business transformation, IBM generated more e-business revenue and profit in 1999 than all the top Internet companies—such as Yahoo!, America Online, Amazon.com, eBay, and E*Trade—combined.[29]

From an e-procurement standpoint, IBM today buys 98 percent of its goods through the Internet. Everything from office supplies to computer components are ordered online from 31,000 suppliers around the world. To do this, IBM uses e-catalogs, as well as a variety of electronic auctions. Through the third quarter of 2001, IBM purchased $30B in goods online and saved $284M in the process.[30]

Today, IBM's e-procurement processes consist of tens of thousands of suppliers, hundreds of millions of products, and tens of thousands of catalogs for more than 300,000 IBM buyers.[31] Their offerings in e-procurement include catalogs, contract procurement, auctions, strategy and consulting services, hosting, systems integration, and security.[32] In addition, IBM uses a fully integrated ETE procurement system internally and is currently proposing such systems to government organizations.

The advantages of e-procurement discussed have had a powerful effect not only on small dot com *firms but also on large, established companies in the United States.*

Figure 3. ***IBM E-Business*** **Web Site (www.ibm.com)**

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One of the main advantages that IBM discovered with the implementation of e-procurement was increased control over purchasing. In the late 1980s and early 1990s, IBM noticed a significant increase in what is termed *maverick buying*. Maverick buying is when employees *go around* the procurement process to avoid the bureaucracy. However, many times, the firm ends up paying higher prices as a result of maverick buying. When IBM began the e-procurement reengineering initiative, 60 percent of the employees said they were dissatisfied with the current processes. Within IBM, it typically took 30 days to process a purchase order, contracts averaged more than 40 pages, and the entire contract cycle took 6 months to a year.[33] Maverick buying plummeted after the implementation of e-procurement.

While improved control over purchasing was a significant advance in IBM, a more significant change involved the role that information technology played in the company. No longer were the chief information officer and the information technology function seen as back office personnel and functions, such as payroll and billing. Instead, IBM views technology as an agent for cutting costs.[34]

IBM's success with e-business has not gone unnoticed by the Defense Department. Executives from IBM frequently discuss their lessons learned with senior military leaders from all the Services in forums such as the Center for Executive Education at the Naval Postgraduate School. Within the Air Force, IBM officials have briefed the senior leaders at Headquarters AFMC.[35] DoD leaders are certainly interested in strategic change in their business processes of the magnitude of IBM's. Nevertheless, the military's efforts with e-business, particularly e-procurement, have been very small relative to IBM's.

E-Procurement and the Department of Defense

Since the mid-1990s, nearly all federal departments and agencies have embraced some e-business practices. Because of the scope and dollar values of its procurement processes, the Defense Department has been the most interested in e-procurement.

DoD's Central Electronic Business Program Office

To facilitate the overall transition to e-business, the Secretary of Defense established the Joint Electronic Commerce Program Office (JECPO) in May 1998.[36] The charter of JECPO was to "support, facilitate, and accelerate the application of e-business practices and associated information technologies to improve DoD processes and support weapons and combat support systems throughout their life cycles."[37]

One of JECPO's first tasks was to construct the *DoD E-Mall*, which provides search capability across all Internet-based DoD electronic catalogs, as well as a number of commercial catalogs. In fiscal year (FY) 2000, E-Mall contained nearly 5 million items and processed $78.8M in transactions.[38]

In 2001, JECPO was renamed the Defense Electronic Business Program Office (DEBPO). Headed by a senior DoD civilian with an Air Force colonel as the deputy, DEBPO developed the DoD Strategic eBusiness Vision:

> By 2010, an enterprise-wide electronic environment will exist where best business practices and enabling technologies are used to facilitate the most efficient exchange of the full range of business information, resulting in streamlined and rapid response to the warfighter and supporting the defense missions.[39]

With the exception of the establishment of the DoD E-Mall, DEBPO has primarily functioned as an information exchange for the best e-business practices across the Defense Department. DEBPO provides DoD education and training organizations with e-business resources for the classroom.

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End-to-End Procurement in the Defense Department

For the most part, the Defense Department has pursued e-procurement by focusing on ETE procurement systems for all acquisitions more than $2,500.[40] As mentioned, ETE consists of a seamless system that integrates all phases of acquiring a good or service, including contract writing, purchase request generation, vendor sourcing, payment, contract award, and contract closeout. Currently, 23 different aging systems provide these functions, which can lead to numerous accounting errors because of the manual data entry required throughout the process.[41]

In fiscal year 2000, E-Mall contained nearly 5 million items and processed $78.8M in transactions.

In December 1998, Defense Reform Initiative Directive No 47 established an integrated process team (IPT) chaired by the Defense Contract Management Agency and the Defense Finance and Accounting Service to develop a model of ETE for the Defense Department.[42] Currently, the ETE Procurement Process IPT is composed of more than 150 DoD and industry participants.[43] With the overall goal of linking these current systems and eliminating those that are duplicative, the ETE Procurement Process IPT has developed system maps, which step through the ETE process and identify all the interfaces. Future plans include building a DoD-wide ETE implementation plan, developing metrics, writing new business rules, and seeking to change language within the Federal Acquisition Regulation.[44] While the ETE Procurement Process IPT has made significant progress, ETE is still 4 to 5 years away from being fully implemented in the Defense Department.[45]

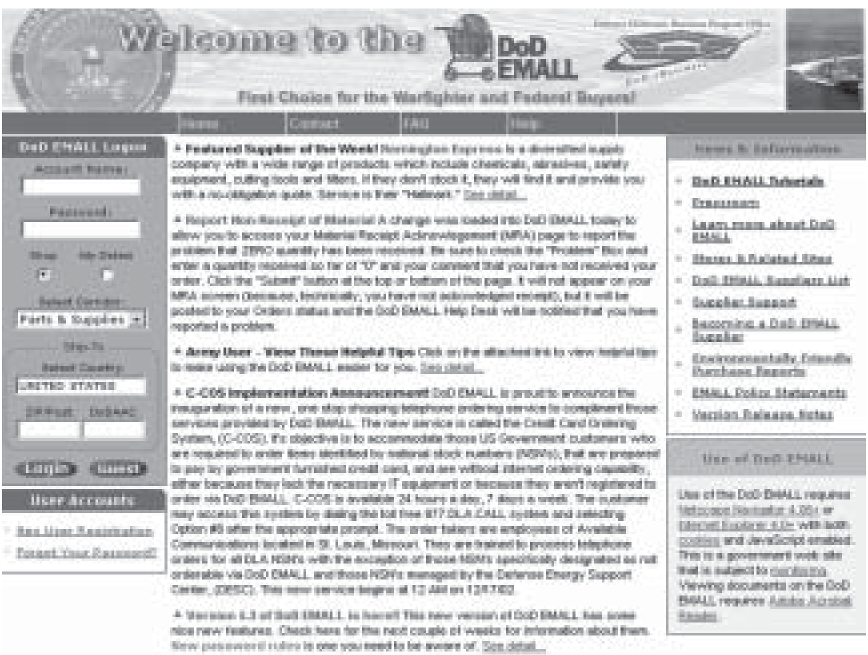

Figure 4. ***DoD E-Mall*** **Web Site (www.emall.dla.mil)**

The Military Departments and E-Procurement

Among the military departments, the Navy, along with the Marine Corps, seems to be the most aggressive in examining and implementing e-procurement processes. Meanwhile, the Air Force is somewhat behind the Navy, while the Army appears to have done the least of the three in the e-procurement arena. Recently, the Army Forces Command used reverse auctions to purchase computers and saved nearly 11 percent.[46] However, because the Army is mostly following the leads of the other departments in e-procurement, only the Navy and the Air Force will be addressed.

For the most part, the Defense Department has pursued e-procurement by focusing on ETE procurement systems for all acquisitions.

The Navy and E-Procurement

Of the military departments, the Navy is the furthest ahead in implementing Web-based tools into its procurement processes. One of the keys to the Navy's success has been the recognition of the need for an overall strategy for e-procurement within the service. Advocated by officials as high as the Under Secretary of the Navy, this strategy allows the Navy to integrate functional stovepipes—such as

Figure 5. *DEBPO* Web Site (www.defenselink.mil/acq/ebusiness)

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contracting, finance, and logistics—that often hinder any widespread and lasting changes to procurement processes.

In September 2000, the Navy established the Department of the Navy E-Business Operations Office with overall responsibility for implementing and integrating Navy e-business efforts. Led by a flag officer with a small cadre of military and civil service personnel, the E-Business Operations Office is part of the Naval Supply Systems Command (NAVSUP) at Mechanicsburg, Pennsylvania.[47] NAVSUP is the Navy's logistics arm responsible for supply operations, conventional ordnance, contracting, resale, fuel, and transportation.[48] An innovative feature of the E-Business Office has been a $20M program in which the Navy solicits pilot technology projects from the public and private sectors that can be applied to e-business operations in the Navy. The pilot submission and selection process is conducted via the Internet, and the goal for the initiatives is to demonstrate a proof of concept within at least 90 days.[49]

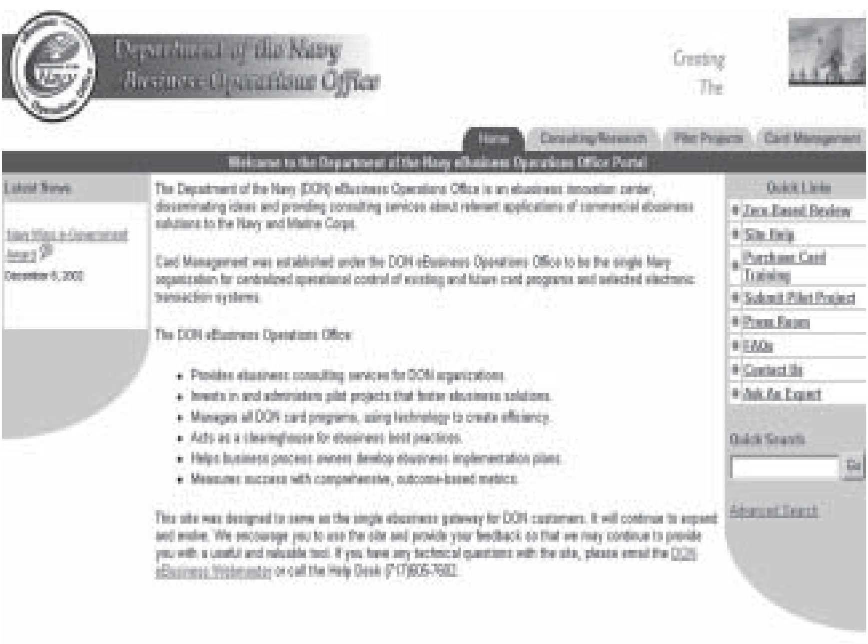

Figure 6. Navy's *Electronic Business* Web Site (www.don-ebusiness.navsup.navy.mil)

At the strategic level, the Navy's E-Business Operations Office has developed a comprehensive plan for the entire Navy, consisting of four goals:

- Maximize the value of Navy investments in systems and infrastructure by incorporating e-business commercial best practices and technologies into the Navy's plans, processes, information management, and information technology architecture and systems.
- Reengineer warfighting support and other core business processes in preparation for e-business technology infusion to maximize Navy mission effectiveness and efficiency.
- Foster the cultural change necessary so that business process reengineering and e-business are embraced and become pervasive.
- Facilitate the creation and sharing of e-business knowledge to enable e-business implementation.[50]

Of the military departments, the Navy is the furthest ahead in implementing Web-based tools into its procurement processes.

At an operational level, the Navy has fully embraced ETE and is an active participant on the DoD ETE Procurement Process IPT. In addition, the Navy is the first of the military departments to fully develop an e-procurement Web site, which is called *One Touch Support.* This is a single-point-of-entry system that allows Navy and Marine Corps personnel to search for supplies and repair parts, check the status of requisitions, and make purchases with the GPC.[51] In the past, personnel would have to search many different databases, each requiring its own ID and password and often using separate terminals to access information now available through the single Web site, *One Touch*.[52]

In addition to establishing a single point of entry into its supply and requirements systems and establishing the framework for a paperless procurement system, the Navy has been successful with reverse auctions. In May 2000, the Navy held a reverse auction for recovery sequencers used in ejection seats. As a result, the Navy saved about $1M and was able to award the contract within 45 minutes of the conclusion of the electronic auction.[53] In June 2000, the Navy held a reverse auction for ship-related services and saved the service almost $3M.[54] More recently, the Navy established a reverse auction to source a contractor to transport the household goods of personnel between

In addition to establishing a single point of entry into its supply and requirements systems and establishing the framework for a paperless procurement system, the Navy has been successful with reverse auctions.

Hawaii and Guam. The Navy planned to spend $3M over 5 years for the contract but, as a result of the auction, ended up spending only $2.1M, a savings of about 30 percent.[55]

All in all, the Navy's relative success with e-procurement seems to be largely due to the fact that it possesses an overall strategy for the implementation of e-business. This strategy starts at the highest levels of Navy leadership and extends to many of its organizations through the efforts of its E-Business Operations Office.

The Air Force and E-Procurement

Unlike the Navy, the Air Force does not have a program office for managing its e-procurement efforts. As a result, it does not have a unifying strategy for Internet-based acquisition, and its e-procurement initiatives are more fragmented and fewer in number than the Navy.

A likely organization to lead overall e-procurement within the Air Force would be the department's contracting office within the Air Staff, Assistant Secretary of the Air Force (SAF), Acquisition. However, SAF Acquisition is currently only responsible for ETE within the Air Force, and within SAF Acquisition, a single lieutenant colonel action officer is the ETE program manager. This lack of high-level oversight creates redundancies within the Air Force for ETE. For example, Langley AFB, Virginia, has attempted to develop a small-scale end-to-end system. However, it is largely duplicative of the ETE Procurement Process IPT's efforts and will likely be terminated soon.

With the Air Staff's managing ETE, the AFMC Contracting Directorate is close to implementing an electronic catalog, called *E-Purchase*, where GPC users can order supplies.[56] Instead of procuring supplies for less than $2,500 from different vendors, E-Purchase will aggregate purchases electronically across the command to take advantage of volume discounts.[57] The Warner Robins Air Logistics Center at Robins AFB, Georgia, already uses a similar, but smaller, catalog for aircraft parts.[58] With these types of e-catalogs, Air Force organizations will be able to track how GPC funds are being spent.[59] Until now, this business *intelligence* data, which are easily available to most commercial firms, have been sorely lacking in the military. Obtaining this type information is truly a significant step for the Air Force and the Defense Department.

Finally, the Air Force has used reverse auctions to a limited extent. In August 2000, the Air Force successfully used a series of reverse auctions to buy computers for the Air Combat Command at Langley AFB. Through these auctions, the Air Force saved about 27 percent of the $325,000 estimated cost for the equipment. One particular auction generated more than a 35-percent savings from the best available price on an existing government contract.[60]

The Air Force does not have a program office for managing its e-procurement efforts.

As can be seen, the Air Force, Navy, and the Defense Department are interested in cost savings and efficiency improvements promised by e-procurement. However, there is still much work to be done.

Recommendations for the Future

On 7 December 2000, when introducing the Navy's new E-Business Operations Office, Deputy Under Secretary of the Navy Charles Nemfakos stated:

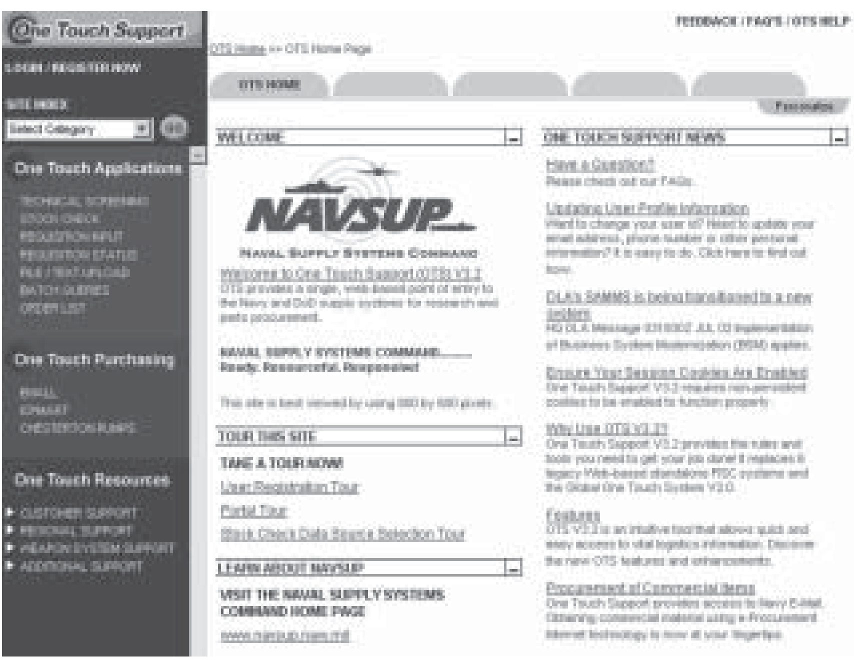

Figure 7. Navy *One Touch Support* Web Site (www.onetouch.navy.mil)

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> For those of you who have been covering the Pentagon for a long time, you know how we normally do things, right? We create organizations, we create bureaucratic means, and we establish processes. Several years later, we actually start doing something.[61]

The Defense Department cannot let this be its approach to e-procurement. In a briefing to the Air Command and Staff College, Norm Augustine, the highly respected chief executive officer (CEO) of Lockheed-Martin, stated that the speed with which business leaders make strategic decisions is of utmost importance. He explained that in an informal survey he did of top CEOs who recently made important strategic decisions for their companies, 90 percent of the CEOs wished they had moved more quickly.[62]

The current revolution in business affairs and the associated transformation discussed by the Secretary of Defense call not only for far-reaching change but also for rapidity in the change process. To harness the benefits of e-procurement, the Defense Department must be prepared to act quickly and wisely. The following are some recommendations for the Defense Department and the military departments to consider as they continue to study and implement e-procurement:

- **The DoD end-to-end IPT must examine bottlenecks in current procurement processes.**

  In the past, the Defense Department or one of the military departments would latch onto a best practice from the commercial world and attempt to overlay it on its own severely broken processes. Some would argue that this was the Air Force experience with Total Quality Management in the early 1990s. The ETE Procurement Process IPT is doing valuable work by examining the entire procurement process with *system maps* and identifying interfaces. However, the IPT must pay careful attention to bottlenecks in the system and realize that technology alone will not solve these problems.

  In an interview, Dr Tom Housel, professor of Information Technology and Acquisition Management at the Naval Postgraduate School, cautioned that there will be few benefits to ETE if bottlenecks are not identified and solved.[63] As an example, in the case of the ETE, an electronic contract may be completed only to have it reside on a clerk's computer somewhere awaiting some final step of approval.

According to Jamie Hewitt, vice president for E-Business Transformation at IBM, one of CEO Lou Gerstner's foremost initiatives in the mid-1990s was to break down and fully understand organizational processes.[64] IBM identified 11 core processes on both the hardware and software sides of the company and then sought to understand the value that each of these processes added to the company.[65] The ETE Procurement Process IPT is doing a similar effort. However, extensive discussions with successful e-business corporations, like IBM and GE, may help the IPT to discover and alleviate bottlenecks in current military procurement systems.

The current revolution in business affairs and the associated transformation discussed by the Secretary of Defense call not only for far-reaching change but also for rapidity in the change process.

- **E-procurement should continue to be adopted by the Defense Department on a command-by-command or organization-by-organization basis.**

One of the tendencies of the Defense Department is to embrace a new program and then mandate it across all the Services. While this may work for a program such as the GPC, this should not be done with e-procurement. Systems must continue to be tailored to fit commands or organizations within the Defense Department. In an interview, Dr Mark Nissen, Assistant Professor of Information Systems and Acquisition Management at the Naval Postgraduate School, warned against attempting to create a *one size fits all* plan for e-procurement across the Defense Department. He explained that large commercial firms have attempted enterprise-wide solutions with other information technology initiatives recently and their efforts have failed.[66]

With its E-Business Operations Office, the Navy is the most advanced of the Services in terms of developing an organizational structure to support e-procurement. The E-Business Operations Office provides vision and goals, as well as some limited oversight of e-procurement across the Navy. Meanwhile, each of the commands is left to decide on

One of the tendencies of the Defense Department is to embrace a new program and then mandate it across all the Services. While this may work for a program such as the GPC, this should not be done with e-procurement.

an approach to e-procurement that best suits its needs. Both the Air Force and the Army lack this overall strategy and could learn much by emulating the Navy in this area.

- **The Defense Department must exploit the advantages of online auctions, reverse auctions, market exchanges, and other e-procurement practices.**

While an end-to-end procurement system may be a long-term effort, the Defense Department and the Services must search for opportunities to use online auctions; reverse auctions; and possibly, market exchanges immediately. Industry has saved large amounts of money from these various forms of e-procurement. For example, while it only started implementing e-business practices in 1999, General Electric conducted a massive push with online auctions in 2000. In 2001, GE established $14B in auctions company wide and anticipated $600M in savings as a result.[67]

In the past, the Federal Acquisition Regulation prohibited auctions, but with dramatic new contracting initiatives, government procurement officials are given much more latitude to exercise sound business judgment in their contracting decisions.[68] With all the common goods and services procured across the military, an effort must be made to establish more online auctions and reverse auctions. In addition, opportunities may exist for the Services to combine their purchasing powers and implement market exchanges, similar to those established by large portions of the automobile and aircraft industries.

- **The Defense Department must be prepared to change the acquisition culture as it adopts e-procurement.**

Without a doubt, e-procurement changes the roles and skills required of procurement organizations and alters relationships with vendors and suppliers. At General Electric, the greatest hurdle to becoming paperless with e-procurement processes has not been technology but culture. Initially, managers had to carefully watch employees using telephones or fax machines to order supplies. Some offices within GE closed their mailrooms for all but 1 day a week to stop employees from using regular mail, while others locked the copier rooms except for occasional days when bosses would stand outside the door and demand explanations from those who were unable to shake their old paper habits.[69]

Clearly, the paper-consuming habits of DoD procurement personnel will have to change to reap the benefits of e-procurement. However, as Lieutenant General Leslie Kenne, commander of the Air Force Electronic Systems Center at Hanscom AFB, Massachusetts, points out, “Organizations, particularly military ones, are notoriously rigid and resistant to change.”[70] In the technology-driven procurement environment of the future, acquisition professionals must become more flexible and adaptable.

In the past, the Federal Acquisition Regulation prohibited auctions, but with dramatic new contracting initiatives, government procurement officials are given much more latitude to exercise sound business judgment in their contracting decisions.

The Acquisition 2005 Task Force Report, “Shaping the Civilian Acquisition Workforce of the Future,” warns that 50 percent of this skilled workforce will be eligible to retire by 2005.[71] While it certainly can be viewed as a threat to the ability to field weapon systems for the warfighters, this change can also be seen as an opportunity to educate the next generation of acquisition professionals in e-procurement. If the results are similar to industry, the Defense Department will need fewer procurement specialists than in the past, and those that do remain will be less administrative and more strategic in function.

- **E-procurement must become a strategic focus of the US military, particularly within the Air Force and the Army.**

The success IBM had in the late 1990s can be linked directly to the strategic vision of CEO Lou Gerstner. He identified the need to focus IBM on all forms of e-business. Similar to IBM, the Defense Department must be prepared to make widespread changes in its procurement practices. To do this, e-procurement must have the full attention of senior level leaders in the Defense Department. E-procurement cannot be handled as another program that must go through all the

Clearly, the paper-consuming habits of DoD procurement personnel will have to change to reap the benefits of e-procurement.

bureaucratic wickets in the Pentagon. The implementation of e-procurement demands swift decisions by leaders who are willing to remove organizational impediments.

The Defense Electronic Business Program Office, ETE Procurement Process IPT, and Navy's E-Business Operations Office are all good starting points, but these and other efforts must have the full support of all the senior military leaders of each of the Services. Within the Air Force, a single lieutenant colonel is not enough to advocate and manage end-to-end procurement across the service.

Overall, acquisition has usually been relegated to the end of the line in terms of executive attention, funding, innovation, training, and advancement. To effectively implement e-procurement, this mindset must change. E-procurement and the associated technology must be viewed as a key method to improve efficiency and cut costs.

Conclusion

The costs and efficiency of the acquisition process within the US military, whether for weapon systems or base supplies, has certainly been questioned over the years. Since the mid-1990s, the Defense Department has been closely watching some of America's largest companies as they adopt e-procurement practices to enhance the management of their supply chains. This research effort was launched to examine this rapidly growing area of business called e-procurement; assess the military's interest and effort thus far with Web-based acquisition; and finally, provide recommendations for DoD decisionmakers to consider both now and in the future. This assessment first examined the range of e-procurement venues available today from e-catalogs to market exchanges to end-to-end procurement. In addition, the overall advantages of Web-based acquisition were addressed. Next, the possibilities of e-procurement were reviewed through looking at the successful example of IBM. Given its mission and structure, some may argue that the Defense Department should not even attempt to emulate successful corporations such as IBM and GE. However, embedded in these companies are valuable lessons for the military, such as the way in which IBM intensely analyzed all its procurement processes before automating them. While the Defense Department has not initiated an effort comparable to IBM, there is some interest and success with e-procurement in the military, especially within the Navy. The Navy is proving successful because it possesses a strategic vision and has worked to integrate the functional stovepipes of contracting, finance, and logistics.

The Navy is proving successful because it possesses a strategic vision and has worked to integrate the functional stovepipes of contracting, finance, and logistics.

As a result of this qualitative assessment, several recommendations were provided for the future of e-procurement in the military. A couple of the recommendations addressed the need for the Defense Department to continue certain efforts. For instance, the ETE Procurement Process IPT is on the right track as it seeks to fully understand the procurement process with its system maps. However, the IPT must pay particular attention to bottlenecks and their impact on the efficiency of the entire procurement process. Furthermore, e-procurement must continue to be implemented organization by organization instead of mandating an enterprise-wide solution. Finally, e-procurement must become a strategic focus at the highest levels of the Defense Department and the Services. It cannot be viewed simply as a contracting, finance, or logistics effort but must be a fundamental building block in the effort to transform. Advocacy by leadership will enable the military to change some of the acquisition culture, particularly with respect to the use of duplicative paper in the procurement process. In addition, leadership must push the use of electronic auctions, reverse auctions, and market exchanges. These forms of e-procurement are providing staggering savings to companies such as IBM, GE, and Boeing and should be used extensively in the military.

Recommendations for Future Study

The research for this article was qualitative in nature. Quantitative analyses of the costs and benefits of implementing ETE systems within military organizations should be done. For some smaller organizations, it may prove to be more costly over the long run to implement ETE than to continue with current procurement methods.

Ultimately, the success of e-procurement in the military will depend on the willingness of senior leaders to see electronic forms of business as vital components in the revolution in business affairs.

In addition, detailed quantitative analyses of the costs and benefits experienced by industry with electronic auctions, reverse auctions, and market exchanges would be useful. The savings achieved by these forms of e-procurement seem to be significant, but there may be some hidden costs and difficulties that are not readily observable.

Ultimately, the success of e-procurement in the military will depend on the willingness of senior leaders to see electronic forms of business as vital components in the revolution in business affairs. Commercial industry realizes that procurement and information technology can no longer stand alone but must be completely integrated into all processes. This, too, must be the approach of the military as it embarks on transformation in the 21st century.

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Notable Quotes

Logistic considerations belong not only in the highest echelons of military planning during the process of preparation for war and for specific wartime operations, but may well become the controlling element with relation to timing and successful operation.

Vice Adm Oscar C. Badger, USN

It is no great matter to change tactical plans in a hurry and to send troops off in new directions. But adjusting supply plans to the altered tactical scheme is far more difficult.

Gen Walter Bedell Smith, USA

Do what is right, not what you think the higher headquarters wants or what you think will make you look good.

Gen Norman Schwarzkopf, USA

Mobility is the true test of a supply system.

B. H. Liddell Hart

It may be of interest to future generals to realize that one makes plans to fit circumstances and does not try to create circumstances to fit plans. That way lies danger.

Gen George S. Patton, Jr, USA

Contractors on the battlefield

Major George (Sam) Hammontree III, USA

Introduction

I don't know what the hell this "logistics" is that Marshall is always talking about, but I want some of it.[1]

—Fleet Admiral E. J. King to a Staff Officer, 1942

Contractors on the battlefield is a growing concern at all echelons for a myriad of reasons. The greatest hurdle in the planning and requisition of contractors on the battlefield is the lack of a fundamental understanding of contractor deployment, force protection, and support requirements. There are three types of contractors, which are categorized by the type of support provided on the battlefield: theater support, external support, and system contractors.[1] Why is understanding the basics of contractors on the battlefield so important? Different types of contractors on the battlefield perform different functions and have unique requirements for deployment integration in the time-phased force deployment data (TPFDD), funding procedures, and contracts that enable the contractors to support the US military in a battlefield environment.[2]

At the tactical level, logisticians, maintainers, and materiel managers try to juggle planning and deployment issues with frequent obstacles such as personnel shortages, split-base operations, logistical forecasts, and budgeting restraints. System contractors can assist the tactical commander with technical expertise on newly upgraded or recently fielded equipment. Traditional roles of system contractors are most frequently associated with logistics and maintenance support functions. With the integration of technology and tactics, such as complex video and communication systems and unmanned aerial vehicles, into the battlespace, system contractors are providing more support closer to the hostile fire. As the traditional concept of the forward edge of the battle area continues to fade in asymmetrical warfare, the necessity of these contractors will bring them closer to the adversaries.

At the operational level, planners consider integrating external and theater support contractors into current and contingency operations. Contractors available from host-nation resources can augment the military with reception, positioning of facilities, materiel management, supply support and maintenance, movement management, and distribution. Contractors also can provide assistance with sanitation facilities, transportation, and minor construction.[3] Contracting personnel can procure most of these functions, as well as commercial support for operations at aerial and sea ports of debarkation.

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The Army is a strong advocate of *training the way you are going to fight*; however, this concept is not applied adequately to contractor support. The military enjoys the knowledge and expertise of various services provided by contractors in garrison. The dependence on contractor support on in garrison must be addressed in contingency or deployment planning. Contractors are a force multiplier in garrison and on the battlefield. A technique used to determine the continuity of contractor support from garrison to the battlefield is to ask each contractor directly who provides mission support, "What provisions are in your contract to deploy with my unit to combat, and how are you getting there?" If a contractor in garrison is not designated to deploy with your unit, raise the issue in your chain of command and include your concerns in the monthly unit status report.

The biggest hurdle in planning and coordinating contractor support on the battlefield is the basic lack of understanding of contractors on the battlefield. Confusing contractor support requirements often leads to a deficit of resources or an overexpenditure of resources to ensure adequate support is in place for deployable systems. The reliance of contractor support in garrison is often convoluted and may not reflect the actual contractor support required on the battlefield.

Background: Roles and Importance of Contractors on the Battlefield

Civilians have established themselves as an integral and vital part of the Department of Defense's total force team. With *distinction, they perform critical duties in virtually every functional area of combat support and combat service support, both at home and abroad.*[4]

—AFPAM 10-231,
Federal Civilian Deployment Guide

Contractors on the battlefield have played a vital role in the nature of war for centuries. The United States began its own revolution with the augmentation of contractors on the battlefield and has continued to use them.[5] If contractors have played a part in conflicts since this nation was founded, why does each new generation have to relearn the lessons associated with integrating this old practice into new conflicts?

In the past, two predominant reasons have kept contractors on the battlefield from becoming a doctrinally recognized part of military planning: a lack of recognition and a lack of doctrine. During past conflicts, contractor support has not been highly publicized. Many civilians and military members do not realize the impact contractors have had on the battlefield; yet contractors' contributions on the battlefield have been instrumental in mission success.[6] Furthermore, as conflicts and wars terminate, efforts to capture lessons learned from the contractors on the battlefield have had little emphasis. The Army has addressed this issue, and tremendous progress has been made by establishing regulations, field manuals (FM), training, tactics and procedures regarding contractors on the battlefield. These products are under constant review and revision to ensure the successful use of contractors on the battlefield. Table 1 provides a historical comparison of the ratios of contractors to the military on the battlefield.

The Three Types of Contractors on the Battlefield

The improvement of the understanding is for two ends; first, our own increase of knowledge; secondly to enable us to deliver that knowledge to others.[8]

—Locke

As doctrine and terminology of contractors on the battlefield are developed, it is important to understand the definitions of the different types of contractors that occupy

Each type of contractor requires different considerations in contract procurement, tracking management, support, and force protection. Furthermore, some contracts may dictate their incorporation in the TPFDD.

War/Conflict	Civilians	Military	Ratio
Revolution	1,500 (est)	9,000(est)	1:60 (est)
Mexican/ American	6,000 (est)	33,000	1:60 (est)
Civil War	200,000	1,000,000	1:50 (est)
World War I	85,000	2,000,000	1:20
World War II	734,000	5,400,000	1:70
Korea	156,000	393,000	1:2.5
Vietnam	70,000	359,000	1:60
Desert Storm	9,000	400,000+	1:50
Bosnia	300	3,000	1:10

Table 1. Civilian Participation in Conflicts and Wars[7]

the battlefield and their requirements. Why is understanding the different types of contractors so important? Each type of contractor requires different considerations in contract procurement, tracking management, support, and force protection. Furthermore, some contracts may dictate their incorporation in the TPFDD. The three types of contractor support are referred to as theater support contractors, external support contractors, and systems contractors.[9]

Theater Support Contractors

No one knows better than I the tremendous work that Brown and Root has done in Somalia. The flexibility and competence demonstrated by your employees were key factors in allowing US forces to transition logistical support to the UN….

—John M. Shalikashvili,
Chairman of the Joint Chiefs of Staff[10]

Theater-support contractors perform services that are oriented to the immediate needs of the operational commander.[11] Services such as light construction, port operations, transportation, and security augmentation are examples of support that fall into this category. Some historic examples of services provided by theater-support contractors are loading and downloading of the aircraft involved during the Berlin Airlift and the stevedores that provided port service during US involvement in Vietnam in the 1960s and 1970s.[12] This begs the question, "How are these contracts procured?"

Generally, theater-support contractors are procured from the principal assistant responsible for contracting. This assistant is the commander's senior acquisition advisor responsible for planning and managing all theater-support contractors.[13] The urgency of the contract and magnitude of the cost will determine which venue is used to obtain the contractors. Theater-support contractors are also more likely to have more indigenous or host-nation contractors because of the nature of services being provided. While the commander is responsible for the safety and security of the contractors, there is normally no requirement for their integration into the TPFDD. However, they should be coordinated and included in operational plans so their administrative and logistical requirements will be identified to the appropriate planners.[14]

What are the options for unplanned and unexpected theater support contractors? Military contracting officers follow operational principles and guidelines to acquire the needed contractor support.

> (Military) contracting is an integral part of supporting Army forces. It is a tool that units and the acquisition community use to obtain goods or services in support of their missions. Contracting support bridges gaps that occur as military logistics resources are being mobilized and may be necessary for the duration of the contingency. Contracting is valuable where host-nation support (HNS) agreements do not exist or where HNS agreements do not provide for all the supplies or services required.
>
> ***—FM 100-10-2***

If contractor support is required, the contracting officer coordinates with the appropriate staff directorates (G1, G2, G3, G4, G5, and G6) and US Embassy for recommendations to ensure the contract complies with host-nation agreements. Satisfying support requirements by contracting indigenous resources improves response time and frees airlift and sealift assets for other priority needs. Contingency contracting support, along with the Logistics Civil Augmentation Program (LOGCAP) and the host nation, complements but doesn't replace available and operational military support systems. Figure 1 provides a theater support contractor diagram.[15]

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External Support Contractors

> *External support contractors provide support to deployed operational forces in a manner separate and distinct from either theater support or system contractors.*
>
> ***—FM 3-100.21***

Mission-enhancing system contractors provide assistance for equipment that is newly fielded, modified, or technically and maintenance intensive. New and upgraded fielded equipment is normally accompanied with a field service representative.

External support contractors provide the combatant commander and staff the capability to use preplanned contractor support to augment support capabilities through the LOGCAP umbrella, contingency contracting from LOGCAP, and the Air Force Contract Augmentation Program.[16] For example, a task force designated to participate in a peacekeeping deployment will require general ground and intermediate aviation maintenance support. The maintenance companies are not designed by their Modified Table of Organization and Equipment (MTOE) to conduct extended maintenance over protracted areas. The companies also have a support responsibility to customers at their home station. The Army Service Component Commander can incorporate external support contractors to fill the void of military capabilities with agencies such as LOGCAP.

System Contractors

System contractors provide support to materiel systems. Most of the system contractors provide support that enhances readiness and continuity in training on advanced or recently fielded systems. However, some system contractors perform maintenance and operations that are unique to the military. These system contractors perform services that have no military counterpart and are required in both peacetime and contingency operations. Currently, there is no doctrinal definition to distinguish between these types of system contractors. The differences in these system contractors have a significant impact on priority for planners. In this article, system contractors are categorized as mission enhancing and mission essential.

Mission-enhancing system contractors provide assistance for equipment that is newly fielded, modified, or technically and maintenance intensive. New and upgraded fielded equipment is normally accompanied with a field service representative. The field service representative is a contractor with an inordinate amount of experience or developmental knowledge on the equipment. These contractors are supplied from the applicable program managers from periods of 1 to 3 years depending on the manufacturer, complexity of the system, and the program manager contract. During the warranty, the program manager funds the deployment of the contractor.[17] These

The field service representative is a contractor with an inordinate amount of experience or developmental knowledge on the equipment.

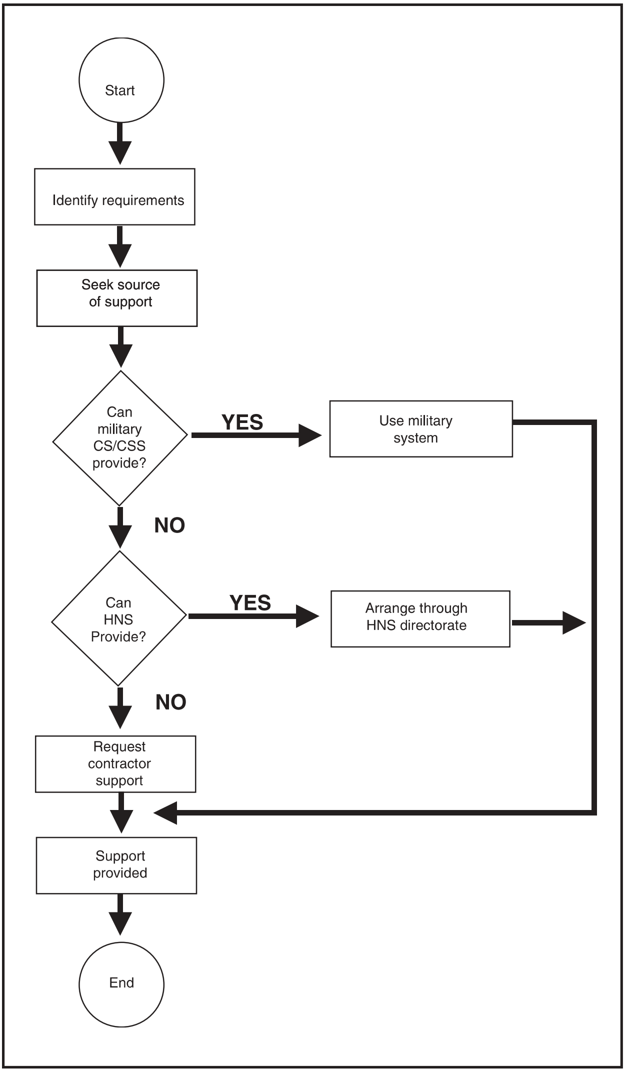

Figure 1. Theater Support Contractor Diagram

contractors are generally one or two people per battalion. Their small numbers, minimal equipment support, and short duration require little disruption in the integration of the deployment phase, which does not mandate their incorporation in the TPFDD.

However, most units continue to use the field service representatives beyond the warranty period to increase

Contractors on the Battlefield

Most units continue to use the field service representatives beyond the warranty period to increase readiness and maintain a training depth in maintenance.

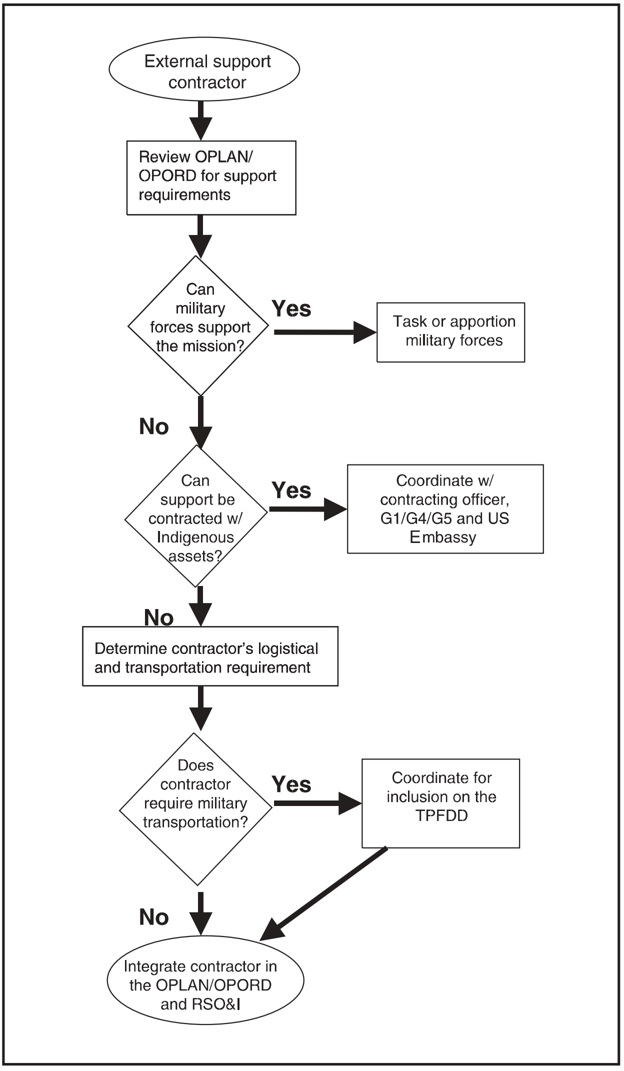

Figure 2. External Support Contractor Diagram

readiness and maintain a training depth in maintenance. Mission-enhancing contractor services are still managed through the program manager offices but are paid for by either the unit or installation. Regardless of who pays the bill, a unit that wants contractor assistance during deployments should contact its program manager to ensure there are provisions for its contractors to deploy to a battlefield environment. If the program manager is not funding the contractor service, the service of a contractor in a potentially hostile environment will increase costs dramatically.[18] For budget planning, those costs must be included in budget estimates and contingency operation funding requirements.

Mission-essential system contractors are not augmenting or providing assistance for a system; they are *the* support for the system. Mission-essential system contractors operate and maintain new or highly technological systems that the military cannot maintain internally; for example, unmanned aerial vehicles and the Army Fox contamination detection vehicle.[19]

Mission-essential system contractors are not augmenting or providing assistance for a system; they are the *support for the system. Mission-essential system contractors operate and maintain new or highly technological systems that the military cannot maintain internally.*

Incorporating mission-essential contractors in operations plans and contingency plans is crucial. They are a vital support function and must be included in the TPFDD. Any unit that has mission-essential contractors for direct or general support during peacetime should also review all applicable operations plans and contingency plans to ensure the contractors are included in the TPFDD and their deployment requirements are not in conflict with their contract. Figure 3 provides a diagram for system contractor planning considerations.

Contractor Considerations

War hath no fury like a noncombatant.[20]

—C. E. Montague

Combatant and Noncombatant Status

Two critical issues that make contractors on the battlefield controversial are their proximity to harm's way and force protection issues. Provisions by the military have been made to grant contractors on the battlefield status as *civilians accompanying the force*, which is recognized by the Geneva Convention.[21] How the American perspective categorizes contractors is irrelevant if the enemy does not abide by the Geneva Convention or acknowledge its definitions of combatant, noncombatant, and civilians accompanying the force. Deploying military forces to support US national interests and expecting its adversaries to understand the American perspective of war is naive and unrealistic. Depending on the type of conflict and enemy, contractors will be treated differently during a limited war, total war, or peacekeeping operations.[22]

There are those who hold a firm belief contractors on the battlefield assisting the war machine are just as libel as combatants. Therefore, there is often no moral distinction in targeting an armed combatant and a civilian involved in arming or feeding the combatant.

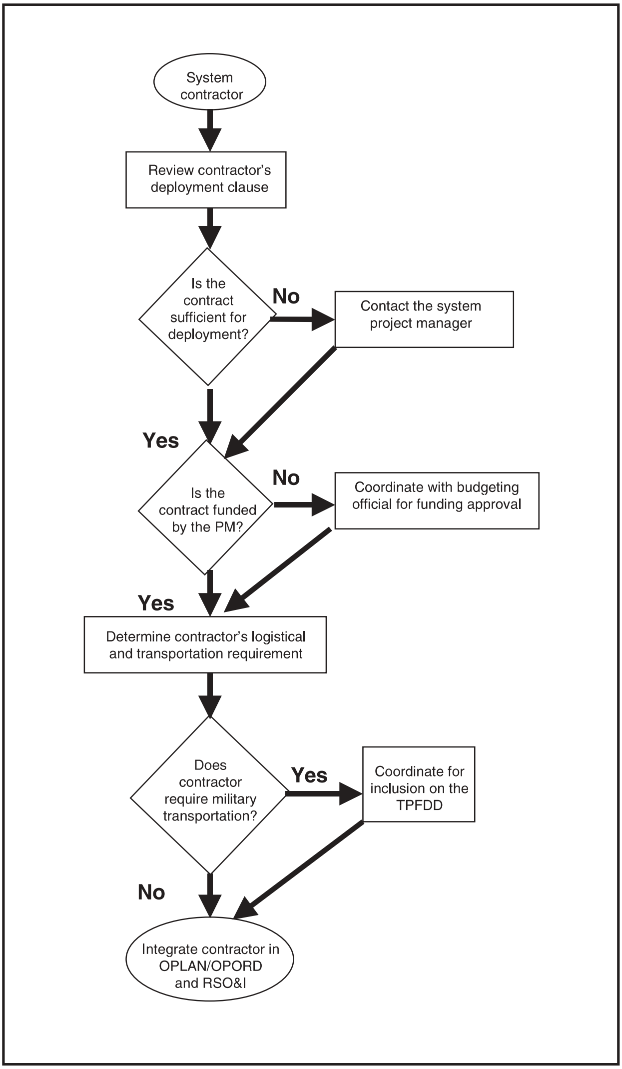

Figure 3. System Contractor Diagram

As system contractors assume more roles as equipment operators, it creates a gray area between the distinctions of civilians accompanying the force and combatants. According to FM 715-9, *Contractors Accompanying the Force*, contractors may not be used in or undertake any role that could jeopardize their status as civilians accompanying the force. Contractors operating unmanned aerial vehicles armed with weapons in a hostile environment require a change in Army regulations and considerations in their protection as civilians.

Limited Wars

Many US military involvements have been limited wars from the American perspective; however, to its adversaries, they have been total war. In the morality of war, *jus in bello* raises the issue of the discrimination of treatment of combatants, noncombatants, and civilians accompanying the force. The participants and nature of warfare often determine if the level of discrimination remains or erodes. There are those who hold a firm belief contractors on the battlefield assisting the war machine are just as libel as combatants. Therefore, there is often no moral distinction in targeting an armed combatant and a civilian involved in arming or feeding the combatant. Provisions for contractors to bear arms for defensive purposes on the battlefield further erode the ability for adversaries to discriminate between the status of combatant and noncombatants.[23] Force protection considerations for contractors on the battlefield should be taken to protect them based on the enemy's perspective and *jus in bello*. Ultimately, it will be the adversaries' perspective that will determine how contractors will be perceived and treated in warfare.

Provisions for contractors to bear arms for defensive purposes on the battlefield further erode the ability for adversaries to discriminate between the status of combatant and noncombatants.

Principles of Contractor Support

> *Using contractors to provide support and services to military operations is not without risks or costs. These basic principles provided the framework for developing doctrine and policy for contractors on the battlefield. They are applicable to contractor efforts today and on the future battlefield.*
>
> **—Joe Fortner**

FM 100-10-2 and FM 3.100.21 outline principles for support by contractors on the battlefield. The basic principles of contractor support should be used to verify requirements. The following principles are not totally inclusive; however, they should be considered when planning or reviewing the use of contractors on the battlefield.[24]

Both ground and aviation maintenance support units do not have the MTOE authorization of equipment and personnel to conduct split-based operations for extended periods and distances. Many of the higher level maintenance functions require external support contractors, either to augment home-based or deployed force operations.

- Depending on mission, enemy, terrain, troops, time, and civilian considerations, contractors may deploy throughout an area of operations and in virtually all conditions.
- Commanders are legally responsible for protecting contractors in their area of operations.
- Contractors must have enough employees with appropriate skills to meet potential requirements.
- Contracted support must be integrated into the overall support plan.
- Contingency plans must ensure continuation of service if a contractor fails to perform.
- Contractor-provided services should be invisible to the users. Any links between Army and contractor automated systems must not place additional burdens on soldiers.

The Army must be capable of providing critical support before contractors arrive in the theater or in the event contractors either do not deploy or cannot continue to provide contracted services.

Although contractors can be used as an alternative source of capabilities at theater or corps level, commanders must remain aware that, within a given operation, using contractors could decrease flexibility.

- Changing contractor activities to meet shifting operational requirements may require contract modifications.
- Contractors are not Government employees; only contractors can manage and supervise their employees.[25]

In accordance with FM 715-9, contractor employee contractors generally are not assigned below echelon above division but may be temporarily deployed forward as needed, consistent with the combatant commander's policy, the tactical situation, and terms and conditions of the contract.[26]

Current Field Requirements and Recommendations

> *The DOD components shall rely on the most effective mix of the total force, cost, and other factors considered, including active, reserve, civilian, host nation, and contract resources necessary to fulfill assigned peacetime and wartime missions.*
>
> **—Department of Defense Instruction 3020.37**

Before contractor requirements are determined, a clear understanding of the type of contractor support is paramount. Peacekeeping operations deploy units as task forces that require split-based support and logistical operations. Both ground and aviation maintenance support units do not have the MTOE authorization of equipment and personnel to conduct split-based operations for extended periods and distances. Many of the higher level maintenance functions require external support contractors, either to augment home-based or deployed force operations. With limitations on the amount of military support authorized to deploy in peacekeeping operations, external contractor support tends to deploy forward to provide support on the battlefield rather than in garrison.

When planning contractor support requirements, there is a substantial numeric difference between the requirements for system and external support contractors who are augmenting MTOE shortfalls. Contractors substituting MTOE capabilities are approximately one for one for support capabilities. Field service representatives are often one or two contractors per battalion and have negligible transportation requirements because of their advisory and training role. Table 2 shows contractor requirements for some critical Army and Air Force systems that require external support and system contractors.

Often 25 percent of a higher level maintenance unit's personnel will deploy in support of peacekeeping operations. More important, the 25 percent deployed may represent 100 percent of a specific system support that still requires support at the home station.

Conclusions

Despite significant efforts to effectively manage LOGCAP, US Army, Europe officials' inexperience and lack of understanding of the contract, the contractor's capabilities, and program management created problems during deployment and resulted in unnecessary costs.[29]

—General Accounting Office Report on Bosnia

An important planning aspect of contractors is understanding the basic concepts associated with contractors on the battlefield. Peacekeeping operations such as Bosnia and Kosovo create challenging curves and loops for logistical planning. Often 25 percent of a higher level maintenance unit's personnel will deploy in support of peacekeeping operations. More important, the 25 percent deployed may represent 100 percent of a specific system support that still requires support at the home station. This void is normally filled by contractors in garrison. Furthermore, external contractors are hired to fill the same

Service	System	Number of Contractors	Type of Contractor	Battlefield Location	Supply Support
Army	AH64A Apache	10-12 per deployed battalion (BN)	External Support (aviation intermediate maintenance)	Located at a fixed-base facility with aircraft access.	Through-service supply system.
Army	AH64 A and AH64 D Apache	1-2 per BN Boeing and Lockheed Martin Rep	System MSN-N	Collocated with ATK BN.	Through-service supply system.
Army	Patriot	1 FSR per BN Raytheon 1 LAR per BN	System MSN-N	Collocated with BN's maintenance CO (DS and GS).	Through-service supply system
Army	Fox M93A1	2 per Chemical Co with 6 systems	System MSN-E	ISB: Contractors provide unit, DS, and above maintenance support. Deploy forward with excursions as needed.	Contractor provides 100-percent repair parts and supply support.
Army	Wolverine	1 per BN	System MSN-N	Collocated with BN maintenance team.	Through-service supply system.
Air Force	Compass Call EC-130H	3-4 per aircraft	System MSN-E	FSRs deploy with aircraft and assist O-level maintenance.	Internal and service supply system.
Air Force	Senior Scout	2 per aircraft	System MSN-E	FSRs deploy with aircraft and assist O-level maintenance.	Internal and service supply system.

Table 2. Joint Contractor Requirements 1 of 2[27]

Service	System	Number of Contractors	Type of Contractor	Battlefield Location	Supply Support
Army	M1A2 SEP Abrams MBT	1 per fielded BN	External Support FSR	Collocated with organizational maintenance.	Service supply system
Army	M2A3 BFVS	4 per fielded BN	External Support FSR	Collocated with organizational maintenance. 1 military van with special tools and test equipment.	Service supply system and 2 military vans with repair parts
Army	IAV	10 per fielded BN GDLS	External Support NET	Brigade support area, FWD to unit maintenance collection points as mission requires.	Service supply system
Air Force	C-17	2-4 per deployment Boeing	System MSN-E Software support and Engine Engineer	Field engineers deploy with aircraft and normally work out of major staging location.	Service supply system
Air Force	RC135 S Cobra Ball	2-3/aircraft Ratheon 2-3/aircraft Textron	System MSN-E	FSRs deploy with aircraft and provide mission support at FOB.	Big Safari, contractor, and service supply system
Air Force	RC135 U/V/W Rivet Joint	2-3/aircraft Ratheon	System MSN-E	FSRs deploy with aircraft and provide mission support at FOB.	Big Safari, contractor, and service supply system

Table 3. Joint Contractor Requirements 2 of 2[28]

support requirements for the peacekeeping operations in theater, creating a duplication of effort.

What impact does this have on what contractors do on the battlefield? The disconnect has led to a duplication of effort and funds to accomplish mission-support requirements as well as hiding unit readiness issues. If a conflict arose that required 25 percent deployed, who would fill the TPFDD in support of a contingency operation? As decisions are made for contractors on the battlefield, there must be a clear understanding of the numbers and requirements of contractors required to deploy and the impacts on the units that are deploying and those remaining in garrison. Once this assessment has been determined, planners from battalion level to the joint staff level must be informed of contractor requirements. Another key factor that cannot be stressed enough is: "If it is not in the contract, it doesn't happen."[30] The vertical flow of information will allow planners to adjust apportioned forces in the event of peacekeeping operations or in a two-theater operation plan.

Many of the sources in this article have been from the Army's FM 100-10-2, *Contracting on the Battlefield*, and the draft FM 3-100.21 (100-21) *Tactics, Techniques, and Procedures for Contractors on the Battlefield*. There has been and continues to be great emphasis invested in these manuals for reasons outlined in this article. Any planner who is involved with contractors should be intimately familiar with these field manuals. The manuals are extremely functional and easy to understand and will be incorporated into some form of joint doctrine for contractors on the battlefield in the future.

Although understanding the differences between the types of contractors is important, the major issues with regard to contractors on the battlefield is that they are not soldiers, and because they are not, the manner in which they are managed, deployed, supported, and protected is different. If any facet of contractor support—such as how they get to the battlefield, positioning on the battlefield, medical and life-support systems, or force protection issues—is not addressed, the commander has a potential loss of combat effectiveness.[31] Today's operators and logisticians in the planning process must address these issues. As today's military incorporates systems that are highly technical and require contractor support, planning and integration of the contractors on the battlefield is essential to maximize the potential of new technologies.

Although understanding the differences between the types of contractors is important, the major issues with regard to contractors on the battlefield is that they are not soldiers, and because they are not, the manner in which they are managed, deployed, supported, and protected is different.

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Is Agile Logistics Focused Logistics in Hiding?

If you look through today's published doctrine, it would be hard to find a definition of logistics in concert with current doctrine. Where does doctrine define logistics core competencies in a manner that would agree with Air Force Doctrine Document 2-1, *Air Warfare*, which defines effects as "the operational or strategic-level outcomes that Air Force functions are intended to produce"? Why not take that statement and add logistics to it and define effects "as the operational, strategic, and logistics outcome that Air Force functions are intended to produce"? Could the introduction of an effects-based logistics concept improve the Air Force expeditionary combat support concept?

The introduction of logistics in this definition would eliminate the casual approach to preplanning the materials required for the specified outcome intended for the operation. More attention would be directed toward the development of refined logistics procedures and technology that will aid in the battle. With the evolution of just-in-time supply and two-level maintenance, the precision with which logistics requirements can be satisfied has been increased dramatically. That means there is a requirement for a far more integrated relationship between logistics and operations. Because dramatic battlefield successes are achieved increasingly over very short periods of time, the *phases* of a campaign can be moved through much faster. This means that logistics requirements need to focus on anticipating battlefield results and quickly adapting logistics flows to what happens on the battlefield. Instead of being reactionary, logistics must be anticipatory—two steps ahead of the next set of requirements. This is effects-based logistics because, as the battlefield changes, logistics support not only changes but also, if done in an effects-based approach, can be used by the operators to leverage capabilities and shape the branch and sequel courses of action. The rapid response of today's operations will determine the size and amount of logistics support, subsequently requiring a higher speed and accuracy of logistics operations than have ever been attained before. This requirement for rapid logistics support will continue to increase as the new century and a new space-focused mission unfold.

According to current Air Force doctrine, the tenets of agile logistics are defined as time-definite delivery, reachback capability logistics command, control, and global combat support system. These four tenets will be identified as logistics centers of gravity. The desired end states will be deploy, sustain, and protect. The defining points will be the operational mission-capable rate and sustainment.

The cumulative effects of these four centers of gravity could impact the desired effects of an operation or a deployment. The three desired end states summarize the logistics mission during critical elements of an operation—the requirement to deploy, followed with the need to sustain operations while protecting assets. Each of these areas constitutes critical effects of the entire logistics system, which could impact the operation. Logistics functions should be considered as more than simply enablers to the Air Force mission. As Alexander the Great noted centuries ago, effects-based logistics is key to operational campaign success.

Lieutenant Colonel Nancy Stinson, USAF

The pressure of more and more passenger aircraft competing for limited airspace may soon overwhelm the National Airspace System.

Unmanned AirLift
how should we proceed?

This article surveys the strategic requirements that suggest there is a need for unmanned airlift and identifies the fact that the Air Force currently does not have a vision for operating cargo aircraft *automatically*.

Major John T. Budd, USAF

Introduction

Imagine the following types of UAVs, mention of which is intended to stimulate the reader to look beyond the near term to the far future: a CONUS-based, hypersonic transatmospheric aerospace plane capable of overflying any location in the world and returning to base in less than two hours; a high-altitude, global range, indefinite loiter VLO combat UAV; or a very large global range transport capable of providing emergency humanitarian aid without exposing an aircrew to danger.

—USAF Scientific Advisory Board, 1996

The concept of unmanned airlift is certainly not new. In 1995, General Ronald R. Fogleman, Air Force Chief of Staff, chartered *Air Force 2025*, a project directed to determine what capabilities the Air Force would need in the future.[1] When completed, the report identified uninhabited air vehicles (UAV) as one of ten critical leverage systems crucial to the defense of the United States. Additionally, the authors of *Airlift 2025* (the air mobility piece of 2025) concluded the most appropriate global mobility system might be airships used in conjunction with powered and unpowered UAV delivery platforms.[2] Shortly after the presentation of *Airlift 2025*, the USAF Scientific Advisory Board (SAB) released its study on UAVs and combat operations. Having reviewed Air Force roles and missions to determine how these vehicles might contribute to the Service's capabilities, the board identified 22 relevant missions, including refueling tanker and cargo transport, that were applicable for UAV development.[3] Based on their assessment of technology, the board projected tanker aircraft might develop between 2005-2015 and cargo aircraft between 2015-2025.[4] Given the level of interest UAV development has received, one might expect that some study of unmanned airlift might have been accomplished by now, but there has not been one. Therefore, based on recent advancements in technology—coupled with the changes in the security, economic, and strategic environments—the author sought to answer, "How should we proceed to make unmanned airlift a reality?"

This article surveys the strategic requirements that suggest there is a need for unmanned airlift and identifies the fact that the Air Force currently does not have a vision for operating cargo aircraft *automatically*. However, as research shows, the pressure of more and more passenger aircraft competing for limited airspace may soon overwhelm the National Airspace System (NAS).

Although UAV *and* unmanned *are used throughout this article, the envisioned* unmanned *airlifter would routinely carry personnel as auxiliary crew or as passengers.*

To ease the pressure, the Federal Aviation Administration (FAA) and National Aeronautics and Space Administration (NASA) are developing new concepts, technologies, and procedures that will help lay the foundation for unmanned airlift. This article reviews these concepts, technologies, and procedures to support the thesis that one *can* suggest a path to the future, and it includes developing a vision, certain specific

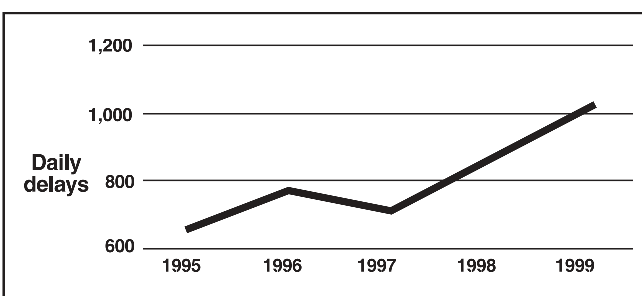

Figure 1. Increasing Air Traffic Delays

technologies, and moving to capitalize on the great advancements currently under development.

Use of Terms

Organizations refer to UAVs in different ways. For example, the FAA used to refer to UAVs as remotely piloted vehicles but now calls them remotely operated aircraft. To avoid creating yet another term for pilotless aircraft and be consistent with current Air Force terminology, this article uses *UAV*, *unmanned airlift*, and *automated airlift* synonymously to indicate an aircraft that carries cargo or passengers but does not require pilots to perform basic flight functions: takeoff, en route control, and landing. Therefore, although *UAV* and *unmanned* are used throughout this article, the envisioned *unmanned* airlifter would routinely carry personnel as auxiliary crew or as passengers. Also, this study applies equally to tanker and cargo aircraft. Because NASA and the Air Force Research Laboratory are developing an automatic refueling capability that would allow aircraft to refuel without the receiver's being able to see the tanker,[5] unmanned airlift also implies unmanned tanker.

The Impetus for Automation

Based on the strategic outlook of the most recent *Quadrennial Defense Review*, the need for unmanned airlift is becoming more apparent. The *Quadrennial* acknowledges capabilities and forces located in the continental United States will be critical to its future military posture, and future expeditionary and forced entry missions may depend on rapidly deployable, highly lethal, and sustainable forces that may come from outside a theater of operations.[6] Furthermore, the Department of Defense will need to provide sufficient mobility, including airlift, to conduct expeditionary operations in distant theaters against adversaries armed with weapons of mass destruction and other means to deny access to US forces.[7] However, the *Quadrennial* points out, "The US military has an existing shortfall in strategic transport aircraft."[8] With the need to provide more power projection and more airlift in the face of greater threats, unmanned airlift may help provide the force enhancements, risk

Currently, neither the Air Force nor the aviation community at large has a vision for unmanned airlift.

reduction, and deterrent capabilities the *Quadrennial* is seeking.

Here is how unmanned airlift can help. First, unmanned airlift and tanker aircraft will not have a limited crew-duty day, so they can project power further, without direct crew constraints. Furthermore, operational tempo can be increased without putting a tremendous strain on limited numbers of aircrew. Second, the nation's political leaders will have a more flexible military instrument of power if they know they can project power without risk to aircrews. This would occur when unmanned tankers are married to unmanned combat aerial vehicles (UCAV) or when airlift aircraft airdrop supplies during humanitarian relief efforts and the threat is unknown. Finally, unmanned power projection should serve as a meaningful deterrent. It is hoped that knowing the United States can strike precisely across almost any distance, with a whole spectrum of force (instead of just cruise or ballistic missiles) will dissuade adversaries from using force against the Untied States or its allies. Surprisingly, however interesting these concepts sound, there has been no planned progress toward unmanned airlift.

Currently, neither the Air Force nor the aviation community at large has a vision for unmanned airlift. According to Major Grant Dick in Air Mobility Command's (AMC) Long-Range Planning Branch, AMC's strategic plan extends to 2018 and does not include the concept of unmanned airlift.[9] Major Lenny Richoux, the air mobility officer at the Headquarters Air Force Strategic Plans Division, confirmed that the Air Force is not currently pursuing pilotless tanker or airlift aircraft.[10] Furthermore, Barth Shenk of the Air Force Research Laboratory acknowledged that the lab has had no requests to do studies into automated airlift.[11] Widening the search, Bob Hilb, manager of Advanced Flight Systems and Future Technologies at United Parcel Service (UPS), said UPS was "not considering it."[12] Surprisingly, the only agency that could be found with an active interest in automated airlift was NASA. In November 2001, NASA contracted with the Applied Research Laboratory at Pennsylvania State University to study the requirements of automated airlift. Ed Crow, head of the Systems and Operation Automation

Division at Pennsylvania State, began the study by trying to find an agency (government or industry) that had a desire to actively pursue unmanned, automated airlift. He found none.[13] This is not to say there is no interest in the subject. Many agencies are talking about it, but if there is someone out there with a vision for unmanned airlift, they are keeping it to themselves. To some degree, this reticence is understandable and worthy of brief investigation.

There seem to be five main reasons why no one has a vision for unmanned airlift. Both Richoux and Grant identified the first reason: no military requirement. Because the Air Force has no specific mission that requires unmanned airlift for completion, it has no vision that includes unmanned airlift.[14] Bob Hilb from UPS identified the second reason: cost and payoff. He said that UPS only invested in technologies that would be cost effective in the near term, and the possibility of unmanned cargo-carrying aircraft lies too far in the future.[15] The third and fourth reasons are intuitive: safety and cultural concerns. How receptive will the public be toward getting on aircraft with no pilot or just having them fly overhead? The final reason is one already discussed: integrating UAV operations in the national and global airspace systems. Currently, there are so many communication, navigation, and surveillance systems, each with varying degrees of coverage, that one cannot construct a single, straightforward operating procedure. When combined, these five reasons create a significant obstacle. No one organization can provide the funding, direction, or operational procedures to overcome them all. However, there are economic and security pressures on NAS that are driving technical, cultural, and organizational revolutions that will redefine how we think about aviation. The planned response to these revolutions will help pave the way for unmanned airlift.

The pressure of more aircraft competing for limited airspace is driving significant changes to NAS. To quantify the problem, Boeing compiled the following statistics (based on pre 9/11 observations): between 1995 and 1999, the Department of Transportation saw a 58- percent increase in aircraft departure delays, and cancellations grew even faster, increasing by 68 percent. During the first 7

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To meet the needs of the 21st century, Marburger argued that the aviation system must include a common infrastructure of communications, navigation, and surveillance equipment that would be secure and allow "all classes of aircraft, from airlines to unpiloted vehicles to operate safely, securely, and efficiently from thousands of communities based on market size and demand."

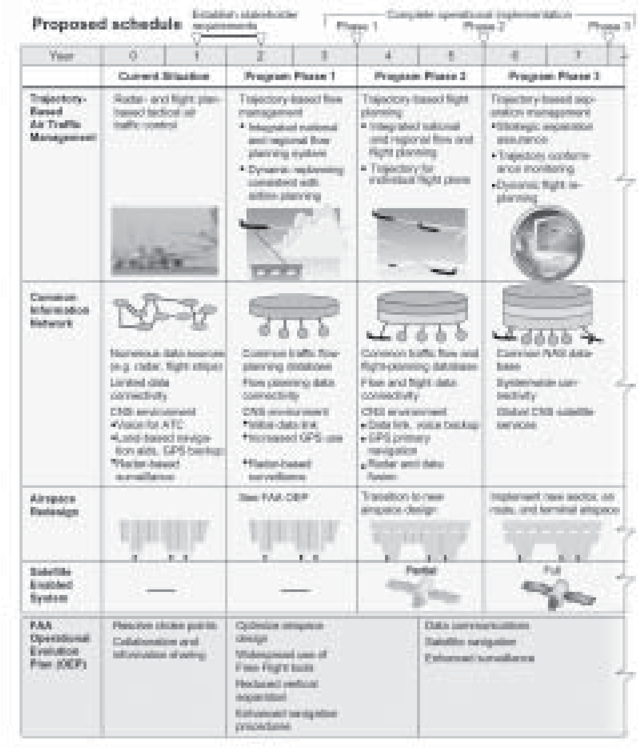

Figure 2. Boeing's Vision for the Evolution of the Air Traffic Management System

months of 2000, more than 90 million passengers arrived late to their destinations or had their flight canceled; and the Air Transport Association estimates that delays cost the US industry, shippers, and passengers more than $5B a year—about $3B in direct airline operating costs and at least $2B in the value of passengers' time.[16] According to John Marburger, the President's Director of the Office of Science and Technology Policy:

> Our air traffic system—based on 1960's technology and management ideas—[is] approaching gridlock, [and]…the current system cannot simply be scaled up to meet projected future growth, especially given the additional measures required to enhance its security.[17]

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Free Flight and the OEP will change the air traffic control paradigm through new concepts, technology, and operating procedures. Expected to be in place by 2010, the OEP envisions greater airspace access through reduced vertical separation between aircraft, reduced lateral separation between aircraft, increased area navigation or point-to-point navigation, and more informed decisionmaking through increased situational awareness for pilots and air traffic controllers.[19] The industry is so enthusiastic about these changes that UPS is busily equipping its aircraft with Automatic Dependent Surveillance—Broadcast (ADS-B). Fed Ex has issued *challenges* to the aviation industry and the FAA to speed up the process.[20] Furthermore, Boeing has created a new corporate division for air traffic management development and has already received permission from the Federal Communications Commission to build a medium earth orbit constellation of satellites to support the common information network (CIN).[21]

To achieve the OEP's goals, there are three core upgrades that must be made to the airspace system: trajectory-based air traffic management, reliance on a common information network, and airspace redesign.

To achieve the OEP's goals, there are three core upgrades that must be made to the airspace system: trajectory-based air traffic management, reliance on a common information network, and airspace redesign. Although Boeing's vision goes a bit further than the FAA's, its depiction of how the airspace system should evolve is extremely illuminating. Trajectory-based flow management allows air traffic controllers to predict aircraft flightpaths and make adjustments (Figure 2). With older systems, the controller had no way to foresee congested airspace or the impact changed routing would have on other traffic. Trajectory-based flow management will allow controllers to view predicted flightpaths up to 40 minutes into the future. This will make potential conflicts much easier to spot and

The common information network is the backbone of the new airspace system. The basic concept is to integrate the communication, navigation, and surveillance systems that service the air traffic management environment.

resolve while giving controllers the information and time to plan for safe avoidance of congestion and delays.[22]

The common information network is the backbone of the new airspace system. The basic concept is to integrate the communication, navigation, and surveillance (CNS) systems that service the air traffic management environment. In Boeing's vision, the network will use secure and encrypted communication links between aircraft, advanced (CNS) satellites, and ground-based users to provide real-time information about aircraft trajectories, weather, and traffic flow (Figure 3).[23]

With the network established, trajectory-based flightpath management will be possible because controllers will receive real-time information about aircraft position, weather, and flight plans. This will also enable the redesign of airspace.

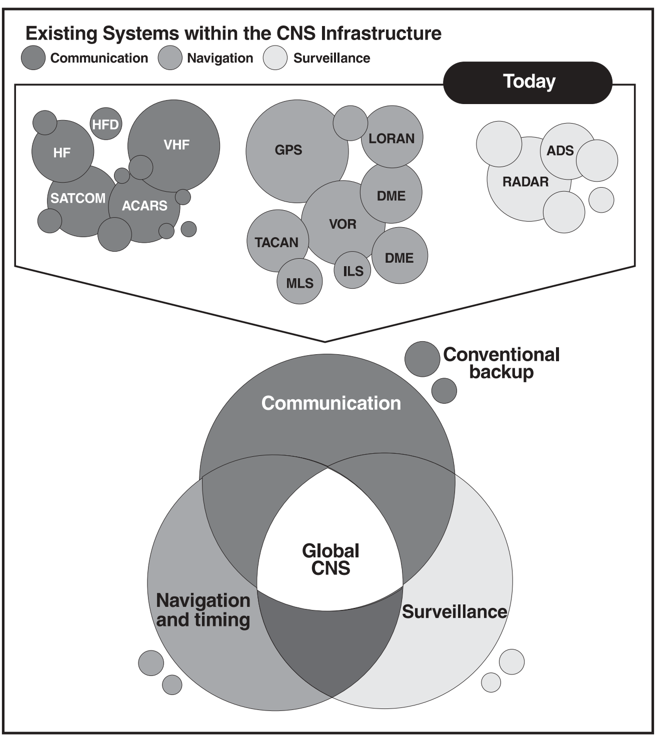

Figure 3. Integration of the CNS Systems

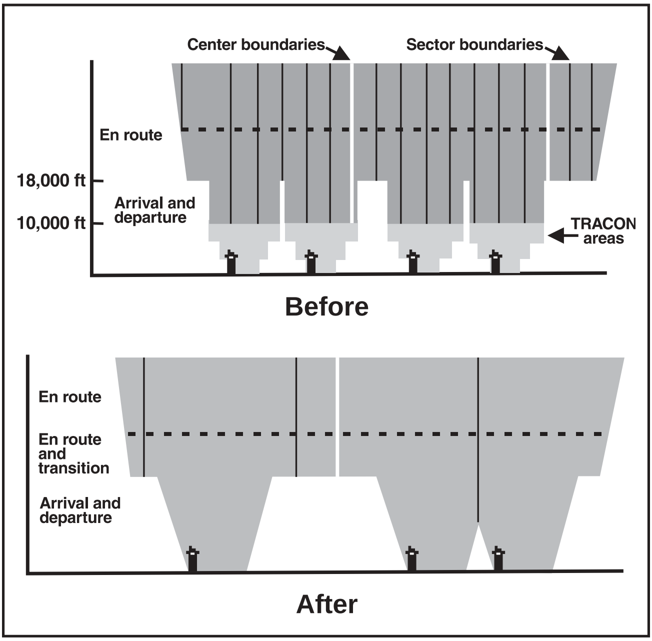

Figure 4. Airspace Redesign

There is another new concept in aviation that will be even more important to clearing the path toward unmanned airlift: NASA's Small Aircraft Transportation System.

The concept of redesigned airspace is really a byproduct of trajectory-based flow management and the common information network. One of the tools being implemented under Free Flight is collaborative decisionmaking, which provides airline operations centers, air traffic controllers, and the FAA's national control center with real-time access to NAS status information, including weather, equipment availability, and delays. This collaboration helps manage the airspace more efficiently.[24] As the support technologies mature, fewer sector controllers will be needed to tactically manage airspace. Collaboration at the national level and trajectory-based flow management should identify and eliminate congestion before it becomes a factor at the sector level (Figure 4).

Taken together, trajectory-based flow control, the common information network, and airspace redesign represent significant steps forward in airspace management. However, there is a new concept in aviation that will be even more important to clearing the path toward unmanned airlift: NASA's Small Aircraft Transportation System (SATS).

SATS has ambitious goals. One such goal is having (in terms of safety and reliability) one SATS pilot equal two Airline Transport Pilot-certified pilots, thus permitting commercial, single-pilot flight operations.

Unlike Free Flight and the OEP, SATS represents a revolution in aviation. Currently, nearly 70 percent of domestic air travelers are forced to fly through fewer than 35 of the nation's more than 18,000 landing facilities. SATS hopes to demonstrate and produce the technology and training necessary for more passengers to travel via small aircraft, point-to-point, in almost any weather, and land at more airfields without the benefit of control towers, radar, or precision instrument approaches.[25] To make this possible, SATS intends to make the aircraft *smarter* by providing pilots with more intuitive guidance. However, SATS has ambitious goals. One such goal is having (in terms of safety and reliability) one SATS pilot equal two Airline Transport Pilot (ATP)-certified pilots, thus permitting commercial, single-pilot flight operations.[26] Furthermore, SATS hopes to reduce intercity doorstep-to-destination transportation time by 50 percent in 10 years and by 67 percent in 25 years, making SATS travel an attractive alternative to hub-and-spoke commercial air travel.[27] As one can see, SATS represents a revolution in air travel concepts, and the technology necessary to deliver SATS will take unmanned airlift forward. However, there is another force that will help propel aviation toward unmanned airlift: the uncertain security environment.

After the tragic terrorist attack on New York and Washington on 11 September 2001, the FAA and other agencies are looking for better ways to maintain control of the skies. According to the Aviation and Transportation Security Act, the Transportation Security Administration (a division of the Department of Transportation) will be required to "identify and undertake research and development activities necessary to enhance transportation security."[28] Steve Pansky, the FAA's manager for Research and Strategic Requirements, explained that this was initially interpreted as a call for better baggage screening and ground security measures. However, there are those who are now looking at monitoring flight conformance and establishing parameters and procedures for taking control of an aircraft in flight (or having the pilot transfer control to the ground) should an incident occur.[29] Although not going as far as taking control of the aircraft, Boeing's air traffic management plan anticipates the need for improved security measures. With Boeing's common information network in place, should a terrorist threat occur, a security administrator could restrict access to airspace by entering the restriction directly into the system, and the system would immediately respond and update the trajectories of all affected aircraft.[30] Because the terrorist attack is so recent, no one has fleshed out exactly how ground control would work, but security against terror in the sky presents another impetus for developing the technologies for unmanned airlift.

No one in the military or industry is willing to admit to a vision of unmanned airlift, so currently there is no well-defined path. However, with the pressure to get more out of the available airspace and do it safely, many exciting technologies will be developed over the next 3-7 years.

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Command and Control of UAVs in the National Airspace System

The technologies and procedures being developed for the OEP will have a direct impact on two key issues facing UAVs operating in NAS: maintaining positive control and maintaining proper aircraft separation.

Perhaps the most important development will be the integration and use of data links for several types of information transfer. First, the FAA and ICAO are introducing direct controller and pilot data link communications (CPDLC) to reduce voice traffic and time spent on routine actions. Eurocontrol completed its first test of CPDLC in the summer of 2001 with US agencies planning to initiate its use soon thereafter.[31] The second type of information to benefit from data link capabilities includes Flight Information Services (FIS) and Terminal Information Service—Broadcast (TIS-B). FIS will provide weather information (to include terminal aerodrome forecasts, meteorological aviation reports, significant meteorological advisories, Airman's Meterological Information Network, and pilot reports) and notices to airmen, while TIS-B provides radar-generated information, including the identity, position, and estimated ground speed of aircraft that are not ADS-B equipped.[32] The FAA is currently developing an ADS-B-based cockpit display of traffic information that will provide the pilot with a

Currently, Boeing is working on data transmission systems that will provide a great deal of information about an aircraft in flight. Called Connexion, this plane-board broadband data link will provide a secure pipeline for transmission and reception of information among aircraft and other users of the common information network.

graphical display of pertinent FIS and TIS-B information. The third type of data (ADS-B) is perhaps the most exciting of them all.

ADS-B is one of the core technologies on which all other changes will be based. It uses an onboard global positioning system (GPS) rather than ground-based radar to determine an aircraft position. Then it broadcasts (over data link) the aircraft's GPS coordinates, which are more accurate than radar, and its velocity, attitude, altitude, identification, and destination to ADS-B aircraft and ground controllers within 150 miles.[33] This capability will enable Free Flight's dream of aircraft flying most places point to point because ADS-B-equipped aircraft will know each other's trajectory and will command the pilot or autopilot to make corrections as necessary to avoid potential conflicts without a controller's input. Furthermore, the accuracy of ADS-B will allow greater use of available runways. For example, at San Francisco, there are two slightly offset runways. United would like to use them both simultaneously. Air Traffic Control is working out procedures that would allow two ADS-B-equipped aircraft to use the runways in non-VMC conditions because the ADS-B tells each pilot exactly where the other aircraft is.[34] Finally, ADS-B represents a tremendous breakthrough in surveillance capabilities. In January 2000, the FAA equipped more than 150 aircraft in Alaska with ADS-B. With the appropriate ground transmitters in place, controllers were able to *see* the satellite data ADS-B aircraft transmit and provide radar vectors. They found the accuracy, frequency, and reliability of ADS-B to be superior to radar as a source of aircraft surveillance information.[35] The final type of information that will benefit from data link capabilities is aircraft systems monitoring.

Currently, Boeing is working on data transmission systems that will provide a great deal of information about an aircraft in flight. Called Connexion, this plane-board broadband data link will provide a secure pipeline for transmission and reception of information among aircraft and other users of the common information network. Connexion will allow near real-time audio, video, and aircraft data monitoring from the ground and from a suit of sensors in the cockpit, cabin, and cargo areas to detect and notify authorities of chemical, explosive, or biological threats.[36]

Although not directly a part of the OEP, the Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) will significantly improve the usefulness of global positioning systems. WAAS is a satellite-based navigation augmentation system designed to warn users when GPS signals are not functioning properly. It also corrects the signals for ionospheric and similar disturbances, making them accurate to within 11.5 feet,[37] giving airfields a GPS-based precision-approach capability. LAAS is a ground-based transmitter that will augment GPS and WAAS signals in the vicinity of the airport. With 1-meter accuracy, LAAS will permit curved, precision-approach paths, category II and III approaches down to zero ceiling and visibility conditions, and airport controllers to track aircraft movement on the ground.[38] WAAS service entry is expected in the 2002-2003 timeframe, while category II and III LAAS production is expected in 2006.[39]

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In addition to collaborative decisionmaking, ADS-B, and data link, there are other tools and services under development by the FAA and Boeing that will have important repercussions on NAS. As part of the OEP, the FAA will implement the User Request Evaluation Tool (URET), Center-Terminal Radar Control Automation System (CTAS), and Traffic Management Advisor. URET is a software tool that can predict an aircraft-to-aircraft conflict 20 minutes ahead. When pilots request changes in their routing, URET will inform the controller of conflicts, allowing the controller to suggest other routing that will be conflict free.[40] The Traffic Management Advisor enables en route controllers and traffic management specialists to develop complete arrival scheduling of properly separated aircraft. These plans then support early runway assignments that maximize an airport's use of its available capacity.[41] CTAS works in conjunction with the Traffic Management Advisor, providing controllers with a time-line display of aircraft approaching the airspace and runways. Controllers can observe potential imbalances and use the data to suggest optimal solutions. While the Traffic Management Advisor

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aids in optimizing traffic flow in the extended airspace around an airport, the CTAS terminal tool helps controllers optimize the flow to touchdown.[42] Boeing hopes to contribute to the effectiveness of these tools with its vision of trajectory-based flight management.

According to Boeing, the fusion of the technology and tools mentioned above will enable dynamic flight replanning and flexible flow control. At the heart of the system will be the National System Flow Model, hosted at the FAA Air Traffic Control System Command Center. This flow model will incorporate aircraft trajectory (airspeed, altitude, heading, and time) for 40 minutes or more into the future, weather information (data linked from national weather service and aircraft sensors), and user requests to anticipate flow problems across the nation.[43] Ultimately, flight plans will be continuously monitored through the National System Flow Model, and required trajectory changes, due to congestion or weather, will be automatically sent via data link to the aircraft.[44] According to Boeing, "The ability to replan flightpaths of airborne aircraft will enable planners to sustain near-normal airspace capacity during disruptive events."[45] These enhanced capabilities provide important guidance for how airlift UAVs will operate in NAS.

The first implications for UAV operations are technical in nature. Upgrades to the GPS system will mean that an unmanned airlifter will be able to use a single source for all its navigational needs. If WAAS and LAAS accuracy is as good as predicted, then combined with precise digitized airfield maps, aircraft will be able to taxi, take off, fly en route, land, and taxi to parking using only GPS signals. Ceiling and visibility will be irrelevant. Upgraded GPS information in conjunction with the use of ADS-B and TIS-B information will allow aircraft to maintain proper spacing from other aircraft, both on the ground and in flight. Because upgrades to NAS represent an evolutionary process, the UAV will still require a low-power radar to have a *see and avoid* capability, which it would require anyway to avoid flocks of birds, ultralights, or other non-ADS-B-equipped flyers. Other changes to NAS technology and procedures have conceptual implications for UAV command and control.

The widespread use of a data link for general aviation will permit a new philosophy of UAV control. Currently, the United States operates two types of UAVs: totally autonomous, like Global Hawk, and pilot dependent, like Predator. In the new NAS, the switch to a data link for issuing controller instructions and dynamic flight planning, in which the system automatically sends updated flight plan information to the cockpit, is ideally suited for automated flight. Because data link information will be transmitted via satellite, it will not matter where the aircraft operator sits. Whether in the aircraft or a ground control station, the same information will be received as long as the operator can receive a satellite signal. Furthermore, the data feed will be digital, which is the ideal medium for use by a computer. Finally, the fusion of traffic, weather, terrain, and flight plan information in a digital display (like the one mentioned above) will provide the single source necessary for decisionmaking. Because the operator, the FAA Air Traffic Control System Command Center, and the controller will have access to the same information, control of UAVs in NAS will be a collaborative effort. Controllers will issue taxi instructions and flight plans via data link, so UAV basic functions—including taxi, a takeoff, en route collision avoidance, and en route altitude and course maintenance—will be performed automatically. Controllers, in coordination with the national command center, will make suggested changes to flight trajectories via a data link, and operators will acknowledge receipt and cross check their accuracy. Therefore, the operator, controller, and aircraft play important roles in maintaining airspace system integrity.

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There is one other point that must be made regarding the operation of UAVs in the airspace system. Most of the discussion has centered on NAS. This limitation is also important because it permits the author to be consistent with dates the technologies will be available. However, the Europeans are already testing data link communications. They are also in the midst of developing ADS-B and their own version of Free Flight.[46] Furthermore, Jane Garvey, FAA administrator, commented on ADS-B: “This technology has the potential of filling huge gaps in radar coverage, including vast areas in South America, Africa, *The most appropriate operators would be pilots because the airmanship a pilot develops by operating in NAS and through mission accomplishment will be required for UAV operations in the foreseeable future.*

and in remote areas of the United States."[47] Finally, Boeing envisions global coverage for the CNS system with its CIN satellite system and has set up offices in Europe and Asia to garner support and acceptance for its proposals. The significance for UAV operation is that a *global* operating environment may not be as far away as one may have thought. However, its development is far less easy to predict than the US system.

Although the discussion has been highly conceptual in nature, it is significant because it is based on changes that are actually occurring to NAS. Economic pressure to get more out of the available airspace is driving the FAA to build a foundation of tools and procedures that favor automated operations.

Changing the Perception of UAV Operator Requirements

In his study, "Piloting the USAF's UAV Fleet: Pilots, Nonrated Officers, Enlisted, or Contractors?" Major Keith Tobin identified three categories of UAVs: high-altitude, tactical, and "all others, which include those UAVs designed to operate within and in combination with manned aircraft and their airspace."[48] He focused on the final category because the type of operator required to fly UAVs in NAS would address the majority of Air Force requirements.[49] In his conclusion, Tobin argued that the most appropriate operators would be pilots because the airmanship a pilot develops by operating in NAS and through mission accomplishment will be required for UAV operations in the foreseeable future.[50] The author challenges this conclusion, not because the argument is faulty, but because the NASA SATS program, in conjunction with the technical changes discussed previously, will fundamentally change what is required to be a pilot and what is required to have airmanship.

The SATS program has three key objectives pertinent to this study. First, enable higher volume operation at nontowered and nonradar airports. SATS technology and procedures will allow simultaneous, all-weather operations by multiple aircraft in nonradar airspace. To accomplish this, aircraft will use vehicle-to-vehicle collaborative sequencing and automated flightpath management systems.

Second, SATS will allow lower landing minimums at minimally equipped landing facilities. Small aircraft will receive precision approach and landing guidance, through the use of graphical flighpath guidance and artificial vision, to any touchdown zone at any landing facility while avoiding land acquisition and approach lighting costs, as well as ground-based precision guidance systems such as instrument landing systems. Finally, SATS intends to increase single-pilot crew safety and mission reliability. Through the use of human-centered automation, intuitive and easy-to-follow flightpath guidance superimposed on a depiction of the outside world, software-enabled flight controls, and an onboard flight planning and management system, SATS expects that one SATS pilot will equal two ATP pilots in safety and reliability.[51] At the very heart of the system is a concept that marries *synthetic vision* with *highway in the sky* (HITS).

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To ensure safe single-pilot operations, NASA intends to employ synthetic vision and HITS technology. Synthetic vision is a 3D projection of the surrounding terrain and obstacles, allowing a pilot to *see* the surroundings even in IMC conditions. Additionally, the HITS display will project a preplanned course *highway* for the pilot, instead of gauges and dials for the pilot to interpret and synthesize into a mental picture of the airplane situation. The graphical display system includes a two-panel display of the GPS position and attitude, course, weather, and aircraft track performance. The integrated flight-display system provides the pilot with an intuitive pictorial for situational awareness and a system that is affordable for use in general aviation aircraft.[52] Both synthetic vision and HITS technologies were developed under the NASA Advanced General Aviation Transportation Experiment program. Now NASA hopes to fuse them with other advancements to help lead a revolution in air transportation. Another key development for safety and pilot reduction is the Cyber Tutor program.

Cyber Tutor will redefine how pilots are trained. In conjunction with the Southeast SATS Lab Consortium, Embry-Riddle University is developing the technology and procedures necessary to significantly reduce the training required to become a pilot. According to Bob

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Peak, technical director, Southeast SATS Lab Consortium, Embry-Riddle has already developed and received approval from the FAA to conduct a course for pilots to gain their pilot's license and an instrument rating *simultaneously*.[53] Building on this progress, the Cyber Tutor program will rely on performance, rather than time-based training. After the appropriate ground and in-flight instruction, the student will be able to go to a SATS aircraft and program the aircraft for a specific flight profile, and the aircraft will direct the student to practice the required flight skills. At the end of the mission, the student will download the flight to disk (or tape) and review the performance with an instructor. The instructor will grade the student's efforts and outline the next profile. Using this performance-based methodology, Peak believes the amount of training required to produce an instrument-rated pilot will be cut in half.[54] This type of training should begin within the next 2 years, when the first SATS aircraft are available. Another enabler of single-pilot operations is the dynamic-approach calculation capability.

It is the dynamic-approach calculation functions that will allow SATS aircraft to operate safely in and around nontowered, nonradar airfields in IMC conditions. SATS will develop vehicle-to-vehicle collaborative sequencing and separation systems that provide time-based flightpath guidance. This flightpath guidance will account for traffic, terrain and obstacles, notices to airmen, and airspace restrictions, while providing efficient flightpath management from takeoff to touchdown.[55] In other words, the aircraft will be able to take into account the factors mentioned above and, in real time, calculate the most appropriate approach to the landing runway, all the while establishing sequencing and maintaining required separation from other traffic. Before discussing SATS implications for unmanned airlift, there are two other technologies that must be discussed.

Boeing's Pilot Associate and NASA's Intelligent Vehicle Research initiative may contribute to the development of safer UAVs. The Pilot Associate program is based on a dynamic human and computer function allocation process for a rotorcraft. The Associate's Cockpit Information Manager (CIM) assesses the rotorcraft pilot's external environment and situation. It also assesses pilot intent based on control inputs and monitors workload. The CIM manages information presented to the pilot and, to the extent allowed, performs certain tasks automatically if the pilot becomes overloaded.[56] The CIM software has been thoroughly ground-tested in simulators and is now in flight test. Boeing is modifying the CIM for application to the UCAV mission.[57] The Intelligent Vehicle Research program will begin with advancements in flight control technology. The first task will be to establish a research flight control system to demonstrate the potentially lifesaving technology of intelligent flight controls that can keep damaged aircraft controllable.[58] Boeing intends to install the system on a C-17 in 2002, and NASA will commence testing at its Dryden Flight Research Center in 2003. This technology, as well as the others mentioned, may have a tremendous impact on progress toward unmanned airlift.

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The SATS program, especially the emphasis on single-pilot operations and significantly reduced pilot training, opens the door for several possibilities. The first is flying airlift and tanker aircraft with only one pilot. SATS will prove that one pilot can operate a small aircraft safely in NAS. Can one pilot operate a larger aircraft just as safely? Only a human analysis study based on demonstrated SATS technology will tell. The most important determination would be how well one pilot performs over a long crew duty day. If one pilot can operate the aircraft safely, then it will permit a *walk then run* process for progress. Single-pilot operations will allow time for testing fully automated procedures with a pilot in the seat, and it will also allow time for building aircraft monitoring and control centers wherever necessary. With the innovation in pilot training, the Air Force also may be able to redefine what it takes to be an airlift pilot. As mentioned earlier, unmanned airlift does not mean that no people will be on board, only that there will be no dedicated pilots. The Air Force currently has flying crew chiefs that fly with the aircraft to perform maintenance when required. If SATS technology makes pilot training truly intuitive, flying crew chiefs may become *pilots* as part of their technical training, with the intent of having them perform emergency landings if ever called upon to do so.

The Air Force must define mission requirements, based on Quadrennial predictions, and adopt unmanned airlift as part of its operational vision.

Another important outcome of SATS is that it will allow time for our culture to change its thinking about what is required to fly an aircraft. If SATS is successful, more people will be exposed to the advanced technology and the ease of single-pilot operations, and it should engender a mindset that aircraft can just about fly themselves. SATS may also help more people become interested in becoming pilots, making them more aware of the advancements being made and how safe aviation automation will be. Furthermore, smart controls such as the Pilot Associate and the Intelligent Vehicle Initiative may add to the sense that aircraft are ready for fully automated operations. Obviously, no one will know how aviation will progress until SATS completes its demonstration in 2005 and the OEP is implemented in 2010. However, economic forces are driving aviation toward automation, and because of SATS and the other innovations discussed, what it takes to be a pilot and how one defines airmanship will change significantly over the next 8 years.

The Path to the Future

Prediction is a risky thing, especially when it's about the future.

—Yogi Berra

Having conducted a survey of emerging technologies, there are steps that must be taken to make unmanned airlift a reality. Most important, the Air Force must define mission requirements, based on *Quadrennial* predictions, and adopt unmanned airlift as part of its operational vision. Even if the Air Force does not spend any money or conduct any studies in the near term, public acknowledgment of the vision could pay big dividends. For example, it is disappointing to think NASA has funded a research project on this subject but could not find anyone who was interested. This is a lost opportunity. Furthermore, public acknowledgment would allow agencies such as the Radio Technician Commission for Aeronautics (RTCA) to begin serious dialogue on the subject. Currently, the Commission includes more than 270 government, industry, and academic organizations from around the world and provides a working forum to guide the operational use of aviation systems and technology in response to airspace user needs.[59] Discussion among RTCA members would help establish the baseline necessary to formulate the common operating procedures of the future. Having publicly acknowledged a plan to operate unmanned mobility aircraft, the next steps follow the development of specific technologies.

As the technologies are realized, they will cue further developments that will help unmanned airlift progress. Between 2005 and 2010, SATS will have demonstrated important enabling technologies, and most of the pieces of the OEP will come into general use. It will be during this time that the Defense Advanced Research Projects Agency (DARPA) and Air Force Research Laboratory should begin work on the *system of systems* that will help control unmanned airlifters in the new NAS. Also, if SATS were able to reach its goal of having one SATS pilot equal two ATP pilots, then it would also be the time to begin serious study on the human factors involved with operating a large aircraft with only one pilot and the Pilot Associate technologies that would be necessary to make it a success. Furthermore, it would be time to review Air Force pilot training requirements in general to see how much they might benefit from SATS developments such as the Cyber Tutor. Finally, if the OEP evolves as planned and the Air Force has success in its human factors study and Pilot Associate development, 2010 would be an appropriate time to petition the FAA for an exemption to applicable Federal Air Regulations so that the Air Force could operate its next airlifter with a single pilot and transition to pilotless operations when ready.

As the technologies are realized, they will cue further developments that will help unmanned airlift progress. Between 2005 and 2010, SATS will have demonstrated important enabling technologies, and most of the pieces of the OEP will come into general use.

Of course, there are other capabilities that need to be developed as well. With LAAS stations coming online after 2006, the possibility exists to develop an automatic aircraft taxi capability. This would be beneficial to manned operations as well, allowing aircraft to move when weather prohibits visual separation procedures. Another very important development would be the procedures necessary to keep aircraft separated during partial or total system failures. Ultimately, this is why control of unmanned airlifters would have to be a collaborative effort, and aerial technicians may need to be on board to provide an emergency landing capability. However, the system would be more resilient than one might expect. With aircraft

The first area for further study would be one of a highly technical nature—what are the ramifications of the entire airline industry's relying on satellite data links, especially with so many other applications in the communications industry turning to that mode of data transfer?

communicating to each other via a data link and to controllers through satellite and ground stations, it would take an extremely capable adversary and a well-coordinated attack to disrupt a meaningful portion of NAS.[60] Ultimately, working out these technical details will take years of coordinated effort and must begin with an operational vision.

Areas for Further Study

The first area for further study would be one of a highly technical nature—what are the ramifications of the entire airline industry's relying on satellite data links, especially with so many other applications in the communications industry turning to that mode of data transfer? Will there be enough bandwidths, and will we have the global common operating procedures necessary to operate UCAVs, UAVs, airlifters, and every other type of aircraft?

The next area for further study is the evolution of the aerial logistics system. In addition to the transformational concepts outlined in the *Quadrennial*, the Air Force is currently developing concepts to support the Global Strike Task Force and the Army its Objective Force. What type of unmanned aircraft will best serve these new constructs? Furthermore, the Army is currently studying airlift, large and small. Recently, the Army received a briefing on the utility of airships that could carry up to 2.2 million pounds of cargo,[61] and they are also seeking funding to begin work on a modular unmanned logistics express (MULE) helicopter that would provide *just in time* logistics delivery to combat troops. How would unmanned airlift, in general, use it in conjunction with the airship and the MULE change the airlift logistics equation?

Finally, this article suggests a new vocabulary for unmanned aircraft. UAV and UCAV do not cover the types of missions that will be accomplished by pilotless aircraft, and they do not accurately describe the type of control required to run the aircraft, as it may be autonomous, collaborative, or directly operated.

Conclusion

This article began with a very interesting observation. Despite the recommendations of two Air Force studies, *Air Force 2025* and the Scientific Advisory Board's *UAV*

Technologies and Combat Operations, the Air Force has not defined requirements for air mobility UAVs. Furthermore, the Air Force does not include unmanned airlift as part of its operational vision for the future. This lack of vision and identified requirements has already led to a setback. In November 2001, NASA contracted with Pennsylvania State to do research on automated (pilotless) cargo-carrying aircraft. Those tasked to do the research could not find any organization, military or commercial, willing to admit to a desire to operate unmanned airlifters. This observation leads to the first conclusion: the Air Force must define military requirements and an operational vision for unmanned airlift. Agencies such as NASA, DARPA, and the Air Force Research Laboratory are ready, willing, and able to conduct research along these lines; they just have not been tasked to do so. This leads to a very important question, "What defines the need for unmanned airlift?"

The Quadrennial, released in September 2001, identifies three requirements that unmanned mobility aircraft could help fulfill.

The *Quadrennial*, released in September 2001, identifies three requirements that unmanned mobility aircraft could help fulfill. The first is an existing shortfall in strategic transport aircraft. The second is the growing need to project power from the continental United States. The third is the ability to project this power in the face of weapons of mass destruction or other means to deny access to US forces. Unmanned mobility aircraft could help meet these requirements in two ways. First, without aircrew duty-day constraints, they could support surge operations without putting a tremendous strain on limited numbers of aircrew. Second, they could operate in the face of greater danger without the risk of losing the crew. These observations underscore the second conclusion: *Quadrennial* requirements provide sufficient guidance to define the need for unmanned airlift. However, having defined the need, there are still major obstacles with operating UAVs in the airspace system.

The third major conclusion is, although the Air Force has not defined a need for unmanned airlift, there are revolutionary concepts being applied to the airspace system that will help make UAV operations more likely. To reduce delays and squeeze more aircraft into limited airspace, the FAA is implementing its OEP. The integrated communication, navigation, and surveillance systems and the common information network technologies that will help make the OEP a success will also produce a more UAV-

Based on the programs and concepts mentioned above, one could sketch a path to the future for unmanned airlift operations. Quadrennial requirements define the need, the evolution of the airspace system defined the common operating environment, and SATS will help redefine our cultural perceptions of the need for pilots.

friendly operating environment in the United States and, in time, overseas. Furthermore, in an effort to eliminate the possibility of terrorists taking control of aircraft, the FAA is investigating the ability to take control of aircraft that are operating outside safe parameters. This automated control from the ground mirrors the requirement for unmanned airlift operations.

Another key development for unmanned airlift operations is NASA's Small Aircraft Transportation System. To help ease the pressures of a crowded airspace system, NASA hopes to develop the technologies necessary to make small aircraft *smart* enough to fly into uncontrolled airfields in almost any weather conditions, with only one pilot. In addition to the automation technologies SATS might add, it will provide the possibility of shifting cultural perceptions of how many pilots are required to fly commercial aircraft. If SATS is successful, it may provide the impetus for commercial and military aircraft to switch to single-pilot operations and, in time, no-pilot operations.

The final conclusion is that, based on the programs and concepts mentioned above, one could sketch a path to the future for unmanned airlift operations. *Quadrennial* requirements define the need, the evolution of the airspace system defined the common operating environment, and SATS will help redefine our cultural perceptions of the need for pilots. This is not to say there are not many other issues to be addressed. Key technologies like the system of systems that will monitor and control unmanned aircraft in flight and automatic taxi systems must still be developed. However, based on the concepts discussed, unmanned airlift could become a frequent and desirable part of military operations and our everyday life.

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Military Logistics and the Warfighter

I think we can all agree there is a relationship between the function of military logistics and the warfighter. What is that relationship, and is it correctly defined? In the early 1960s, there was a stated relationship between logistics and the weapons systems: military logistics "support"' the weapons system. At that time, the subject of military logistics was fairly new and, with little ongoing research, very slow in providing greater *understanding* about it. Therefore, during that period, this definition of relationship seemed appropriate. It was not until the late 1970s that several advocates of military logistics came to the realization that logistics *support* of the weapon system was actually creating and sustaining warfighting capability. This warfighting capability was provided to the combat forces in the form of continuing availability of operational weapon systems (the tools of war). This new awareness set up another definition of the relationship: *military logistics creates and sustains warfighting capability*. While many heard the words, few realized their implications.

The level of warfighting capability that logistics provides the combat forces determines the extent to which war can be waged. This, in turn, limits and shapes how the war will be waged. Warfighting capability is *embedded* in the design of all weapon systems. Advancing technology increases speed, range, maneuverability, ceiling, and firepower, all of which provide more lethal and accurately guided munitions, stealth, and other offensive and defensive warfighting capabilities. They will be embedded into the design of future weapon systems. It is the weapon systems that contain the warfighting capability of military forces. The strength of military forces is no longer measured by the number of men *under arms*. Today, military forces are measured by the number—and warfighting capabilities—of their weapon systems. The Department of Defense has yet to adequately define and manage the total logistics environment (those activities and resources required to create and sustain warfighting capability). While it is said that armies travel on their stomachs, what is usually left unsaid is they perform on the basis of their logistics competency.

Today, as most of you are aware, we have another, more recently defined relationship: *military logistics supports the warfighter*. We know military logistics creates and sustains warfighting capability. We can assume the warfighter fights wars. It would, therefore, appear reasonable to suggest that in order for one to be a warfighter (a pilot in this case) he or she must have the capability to wage war. While weapon systems are designed and created to wage war, people are not. Therefore, in order to become warfighters, pilots must be provided with some level or amount of warfighting capability. I would submit that by providing the pilot with an operational weapon system, which allows him or her to utilize its warfighting capability, *military logistics creates the warfighter*. It does not *support* the warfighter; it *creates* the warfighter. This transformation occurs when a checked-out pilot starts the engine. At that point, the pilot is in control of the weapon system and its warfighting capability. The pilot is now the warfighter. Without the warfighting capability, which the weapons system provides, a pilot is a pilot.

Military logistics creates and sustains warfighting capability; by doing so, military logistics creates and sustains the warfighter.

Colonel Fred Gluck, USAF, Retired

Climbing
An

First, you must win the confidence of the maintainers you lead. Next, you must foster cooperative long-range planning efforts. Finally, you must cement these cultural norms with the next generation of leaders through active mentoring.

Down from the Cockpit

Aviator's Guide to Leading Maintainers

Flying squadrons are made up of two major parts, operations and maintenance. The two may have distinctly different cultures, and their short-term goals and agendas may often be at odds with one another.

Lieutenant Colonel Robert E. Suinsby, Jr, USAF

The following article is written from the perspective of a fighter squadron commander. However, the lessons here apply to any flying squadron that has combined operations and maintenance functions. Furthermore, the principles of cooperation apply even in situations in which operations and maintenance are organized into separate squadrons.

Congratulations! You have just been selected to command a flying squadron! The job of a lifetime, right? Out on the tip of the spear, leading your warriors into combat—what could be better? Ask yourself, How much do I know about the job I am stepping into? Am I ready? In response to a 1996 survey by an Air Command and Staff College research group, 60 percent of former flying squadron commanders answered, "No."[1]

Since the reorganization of the Air Force into the objective wing structure in 1991, fighter squadron commanders have faced a very different set of challenges than their predecessors did in the Cold War era. The reorganization broke up the previous consolidated aircraft maintenance squadron and moved all on-aircraft maintenance functions into fighter squadrons. Overnight, squadron commanders, who had previously commanded an organization made up almost entirely of officers, gained responsibility for hundreds of enlisted people, who performed a mission most aviators had only observed from a distance. As one commander observed, "It is like getting the general manager's job at Denny's because you ate there once."[2]

At the time of the reorganization, Air Force Chief of Staff General Merrill McPeak stated, "Our operations squadron commanders will need to be trained to take on new responsibilities, but I'm confident this will work."[3] Unfortunately, the training that McPeak referred to has never materialized. Precommand training within the Air Force is normally limited to a 1-week course that can only scratch the surface of the broad range of maintenance-related issues a commander encounters. A formal course to teach maintenance basics to prospective flying squadron commanders is once again under consideration at the Air Staff, but for now, 10 years after the reorganization, new commanders must navigate these rocky passages with precious little formal training in aircraft maintenance.

This article offers some advice for prospective flying squadron commanders facing this challenge.

Flying squadrons are made up of two major parts, operations and maintenance. The two may have distinctly different cultures, and their short-term goals and agendas may often be at odds with one another. Because flying squadron commanders grow up through the operations culture, there is a perfectly natural tendency for some maintainers to be suspicious of the commander. Many maintainers fear the commander will always *take the side of the ops guys* when competing agendas force a compromise.

This article offers some advice for prospective flying squadron commanders facing this challenge. Even in the absence of formal training, a new fighter squadron commander can smooth the transition by following the few simple guidelines outlined below. In a nutshell, as a commander, you should strive to develop a culture of cooperation in your organization. First, you must win the confidence of the maintainers you lead. Next, you must foster cooperative long-range planning efforts. Finally, you must cement these cultural norms with the next generation of leaders through active mentoring.

Getting Started

The attitude and personality of a commander have an enormous influence on the organization, and the first few weeks of your command will set the tone. Unless you have significant experience with aircraft maintenance, you will be facing a steep learning curve. The most important thing to understand as a fledgling commander is that while maintainers will respect you by virtue of your rank and position, they have no reason to trust you until you earn that trust. That may seem unfair, but remember, you are probably viewed as an outsider, a product of the ops world. The Air Force has a very technically oriented culture, and technical competence is one of the prerequisites for successful leaders in our service.[4] But technical competence as an aviator does not entitle the new commander to credibility in the maintenance arena. Furthermore, squadron command is the first opportunity most Air Force aviators have to supervise enlisted personnel, and most reach that position with a very limited knowledge of the enlisted promotion system, performance reports, and education and training programs.[5]

Maintainers will initially be alert for signs of a natural bias on the part of the commander. Everyone has biases; good leaders develop the ability to recognize their own biases and compensate for them. In a flying squadron during peacetime, operations personnel are mostly concerned with meeting annual training requirements, and these requirements drive aircraft sortie production demands. Short-notice changes driven by weather, ineffective training, or higher headquarters requirements are a way of life, and a certain degree of turmoil is inevitable. Commanders, who have grown up through this operations culture, have an innate understanding for operations. Maintenance, on the other hand, must attempt to satisfy sortie requirements while keeping a close eye on the health of the aircraft fleet. Maintaining a healthy fleet requires scheduled down time for preventive maintenance, inspections, and accomplishing time-compliance technical orders. Commanders must ensure the operations officer and the squadron maintenance officer are cooperating to strike the proper balance between these often-competing priorities. Leading without bias demands that the commander learn the other half of the *family business*.

Major commands normally offer a senior leaders maintenance course (SLMC) at least once and sometimes twice a year.[6] While the course agendas may vary, the courses themselves generally provide an overview of a broad spectrum of maintenance issues. Unfortunately, the opportunity to attend one of these courses may not occur until months into a commander’s tour. If you have been

The commander's first goals in dealing with the maintenance organization should be to establish trust and build credibility.

selected as a command candidate, fight for the opportunity to attend an SLMC at the earliest opportunity, ideally before assuming command. With or without the course under your belt, the first few weeks of your command tour should be a period of intense education. How you approach this learning opportunity can make or break your relationship with maintenance leadership.

The commander's first goals in dealing with the maintenance organization should be to *establish trust and build credibility*. The following are some simple practical steps in that direction.

- **Dress for Success**. Two-thirds of the typical flying squadron's personnel wear the battle dress uniform everyday. Unfortunately, most aviators regard the flight suit as a second skin and are loath to wear anything else. It is familiar and comfortable, and there is a pocket for everything, including your hat. Get over it. To earn the trust of your troops, you must be willing to dress like them.
- **Get Out of the Office**. You cannot earn much trust behind your desk. The maintenance workforce is normally organized into three shifts, working around the clock. On the very first day on the job, the new commander should visit all three shifts in each work section. Remember, some of these airmen who are working *mids* (typically 2300-0700) were sound asleep in the dorm during your change-of-command ceremony. They don't even know what you look like. Take a few minutes to address each shift, introduce yourself, and outline your philosophy and values. No long speeches, but let people know where your priorities lie. This is a good opportunity to establish your expectations for personal integrity. Let your people know up front that you expect honest reporting of problem areas. Every airman in your squadron deserves to hear this from you personally. Covering all three shifts will make for a very long first day on the job, but it will be worth the effort.
- **Get to Know the Players.** During the first few days, have your squadron maintenance officer take you around to each work section and introduce his senior noncommissioned officers (NCO). Most new commanders have had relatively little experience working with senior NCOs, but a new commander in a flying squadron quickly learns that this level of leadership is absolutely crucial to success. Trite as it may sound, senior NCOs are truly the backbone of your maintenance complex. Because you got to do the talking on your first day on the job, they should have a good idea where you stand. Now it is their turn. Ask them to give you a short overview of their work section, including key personnel and manning issues, facility and equipment issues, and funding concerns. Listen attentively, ask

questions, and take notes. You cannot solve all the problems in the first week, but you can get the pulse of the organization.

- **Give Your Maintainers Room to Lead**. Selection as a squadron commander does not mean you have cornered the market on leadership. There are lots of leaders in your squadron, and many of them wear stripes. The senior NCOs in the squadron have a combined total of hundreds of years' experience fixing airplanes, so let them do their jobs. Make it clear that you are still learning and that they have a responsibility to teach you. That means you may want to hear the *why* along with the *what* until your comfort level increases. Be a good devil's advocate; ask tough questions and make sure the reasoning for a course of action is sound. Trust the experience that these leaders bring to the table—they will repay that trust many times over.

The senior NCOs in the squadron have a combined total of hundreds of years experience fixing airplanes, so let them do their jobs.

These suggestions should help you through the first few weeks on the job. You will not be flying as much as you would like, but you will be laying the groundwork for a successful command tour. What is next? Now that you have an idea of who does what in your maintenance organization, how do you keep it running smoothly? It should come as no surprise that communication lies at the heart of the process. The following are a few tips.

- **Learn the Maintenance Battle Rhythm.** Every wing has its own unique schedule of daily, weekly, and monthly meetings. Chances are, there are a whole series of maintenance meetings you did not even know about. Find out when the meetings occur and who normally attends. Most of the meetings will function just fine without you (in some cases, even better), but knowing when your key leaders are assembled is invaluable when you want a few minutes to discuss an issue or just ask a few questions. Daily, face-to-face communication between the commander and the squadron maintenance officer is essential, but that alone will not teach you everything. The daily production meeting, for example, is the preflight briefing for the day's activities. Make it a habit to drop into these meetings occasionally and just listen. If the previous commander did not do that, the first few times you show up may make people nervous, but they will quickly catch on that you are there to learn.
- **Your Footsteps Show Where Your Interests Lie.** Do not forget the importance of nonverbal communication. Work sections that never see the commander will quickly get the impression that they are both out of sight and out of mind. Very few squadrons have the luxury of having operations, maintenance, and the command section all collocated. This means the commander must make an extra effort to stay visible. You

Daily, face-to-face communication between the commander and the squadron maintenance officer is essential, but that alone will not teach you everything.

cannot be everywhere at once, but take the time to visit every area periodically, especially those that are off the beaten track.

- **Stop, Look, and Listen.** While you are out and about, it should count for more than simply *face tim*e. Take the time to ask questions and get some feedback. Find out if your people are getting the support they need from outside agencies or if the new policy that was just implemented is working or not. If you have done a good job earning their trust as described above, you will get lots of useful information.
- **Do Not Try to Lead by E-mail**. Most commanders will tell you that e-mail is the root of all evil, yet many fall prey to using it as the primary or sole means of communication. Keep in mind that maintenance happens out on the flight line, not in an office. A commander who attempts to lead by e-mail and expects instant responses will find his key leaders spending more and more time behind a desk. Don't allow technology to undermine your leadership.
- **Establish What You Need to Know.** Commanders are held accountable for everything that happens in their squadrons, but no one can be expected to know everything. Do not try. Instead, ask your squadron maintenance officer and other trusted agents, "What do you *need* me to know?" As your technical competence in maintenance issues grows, you may want additional information, but do not allow yourself to become overwhelmed and paralyzed by too much data. At the same time, do not go to the opposite extreme and hide behind your squadron maintenance officer on maintenance issues. At daily status meetings with the group or wing commander, the squadron commander should take the lead. Do not hog the limelight; let your squadron maintenance officer take the credit when there is good news to deliver. But do not expect the squadron maintenance officer to *take any spears* for you on issues like flight-line ground mishaps, damaged components, or missed training appointments.
- **Know When to Butt Out.** As your comfort level grows, resist the temptation to start running the show in maintenance. And keep in mind that the commander is not the person who should be representing the operations perspective to maintenance. That is your operations officer's job, and that person should be talking with the squadron maintenance officer every day. The squadron maintenance officer and operations officer relationship is a delicate one, because, in most cases, the operations officer will be a lieutenant colonel, and the squadron maintenance officer will usually be a major or oftentimes a senior captain. Furthermore, when the commander is off station, the operations officer will normally be designated as the acting squadron commander, so it is tough for your squadron maintenance officer to maintain a peer relationship with the operations officer. Recognize the situation your squadron maintenance officer is in and make sure your operations officer recognizes it as well. Make

sure the squadron maintenance officer is not *getting rolled* by the operations officer because of a rank difference. However, if the relationship between the squadron maintenance officer and operations officer is healthy, stay out of their way. Remember that this may be your operations officer's only opportunity to learn the ins and outs of maintenance before moving up to a command job.

One Team, One Fight: Building a Culture of Cooperation

If both operations and maintenance regard the commander as an honest broker and the squadron maintenance officer and the operations officer cooperate effectively to achieve common goals, it generates a *culture of cooperation* that eventually permeates every level of the organization. Nurturing that culture is perhaps the best investment a commander can make in the long-term health of the squadron.

What is the culture of the squadron you are going to command? Every organization has a culture, "a persistent, patterned way of thinking about the central tasks of and human relationships within an organization. Culture is to an organization what personality is to an individual."[7] No doubt you have seen wings where a certain squadron had the reputation as the *can do* squadron or the *no can do* squadron. That reputation directly reflects the unit's culture. Culture changes slowly, and turning around an adverse culture requires a continuous long-term effort by the organization's leadership.

Keep in mind that the commander is not the person who should be representing the operations perspective to maintenance. That is your operations officer's job, and that person should be talking with the squadron maintenance officer every day.

The most fundamental requirement for cooperation is a shared vision. "If the culture is shared and endorsed across the various subgroups that comprise an organization, then a sense of mission exists, and the organization is relatively cohesive, both internally and in its approach to the outside world."[8] Sound like the kind of squadron you would like to lead? As the commander, you have the lion's share of responsibility for establishing that shared vision. But setting specific goals and, more important, laying out the plan to get you there is best accomplished through cooperative effort, which reinforces the culture you want to establish.

Long-range planning requires a strategic focus. By definition, long-range planning deals with an extended time horizon, and as the time horizon increases, uncertainty increases as well. At the squadron level, long range will

Culture is to an organization what personality is to an individual.

not mean 15-20 years as it might at a major command, but looking even 12 to 18 months ahead is a challenge in a dynamic environment like a flying squadron. Planning in most flying squadrons centers around the annual flying-hour program. This is where the commander applies resources (people, time, and flying-hour dollars) to generate a product: mission-capable aircraft and mission-ready aircrews. Keep that balance in mind: you must train a large group of aviators, while keeping the fleet healthy and ready to go to war. Achieving either one without the other is a failure. Getting both operations and maintenance to recognize that simple fact is the foundation of cooperative planning. As the commander, you must establish a unifying vision that goes beyond simply executing the flying-hour program. That is hardly a goal young Americans would sign up to fight and die for, yet too often, it becomes the *raison d'etre* for a flying squadron.

The chief of scheduling in operations is normally the primary architect of the flying-hour program, but operations cannot build a good flying-hour program in isolation.[9] Maintenance scheduling and supervision must have an equal role in this process to ensure proper flow of aircraft for depot cycles, local phase inspections, aircraft transfers, and other special requirements. Tradeoffs are inevitable, as are changes to adjust the plan throughout the year. But the end product should be a plan that minimizes potential turbulence. Here the culture of cooperation at lower levels pays enormous dividends. If both operations and maintenance have a role in building the flying-hour program, there is a greater commitment to make the plan work. Throughout the process, the squadron commander must maintain the role of honest broker, keeping all parties focused on the higher level goals and vision.

The person who learns the most from this process will probably be your chief of scheduling. This person must rise above the fray of the daily chaos in the typical scheduling office and focus on long-range goals. Close coordination with maintenance may be a new and challenging experience, but keep in mind, you are grooming a future operations officer or commander. When that person is in your shoes, he or she will be far better prepared for the job if you are fulfilling your responsibilities as a mentor.

Making It Last: The Importance of Mentoring Your Officers

As you become more knowledgeable about maintenance issues, you have a responsibility to see that wisdom is passed on to your young officers as well. You may choose to do some of that personally, but do not try to be the sole conduit for mentoring. You have a wealth of resources at your disposal; use them.

The relationship between your aviators and your senior NCO leadership presents a mentoring opportunity that is too often overlooked. Air Force Policy Directive 36-34 defines mentoring as "a relationship in which a person with greater experience and wisdom guides another person to develop both personally and professionally."[10] That definition says nothing about the ranks of the individuals in the mentoring relationship; however, most official references to mentoring only discuss relationships within separate officer or enlisted supervisory chains. But it goes without saying that the typical flight-line production superintendent, a master sergeant with 15 years' or more experience, meets the definition of a person with greater experience and wisdom when dealing with one of the young captains in the scheduling shop. Obviously, this is an informal form of mentoring but a very effective one nonetheless. The maintenance community has known this for years, allowing new lieutenants to learn the ropes from an experienced senior NCO before moving on to positions of increased responsibility.[11] The key to making it work is the culture of cooperation. The squadron maintenance officer and operations officer (to say nothing of the commander) must resist the temptation to solve all conflicts themselves.[12] While the squadron maintenance officer and operations officer should approve changes to the weekly flying schedule, allowing lower level personnel to generate the solutions to conflicts fosters a greater sense of teamwork and allows company grade aviators to learn how operations and maintenance functions interact.

Maintenance scheduling and maintenance supervision must have an equal role in this process to ensure proper flow of aircraft for depot cycles, local phase inspections, aircraft transfers, and other special requirements.

Do not neglect your young maintenance officers either. They will be few in number but vital to your success. Remember that they will grow up to be the squadron maintenance officers and maintenance squadron commanders of tomorrow. Make sure they are getting the mentoring they need in maintenance skills from the squadron maintenance officer and other senior maintainers in the wing. But the responsibility for teaching officership skills and implanting a spirit of cooperation lies first and foremost with you.

Your young aviators may not yet qualify as mentors, but they can be very effective motivators for your young airmen. Most new aviators consider themselves pretty far down the food chain and do not consciously think of themselves as role models or motivators. They need to be

The relationship between your aviators and your senior NCO leadership presents a mentoring opportunity that is too often overlooked.

reminded that, in the eyes of the airmen launching their aircraft, *anyone* who climbs up that boarding ladder, whether a lieutenant or a lieutenant colonel, is somebody important. Make sure your aviators are taking the time to talk to their crew chiefs (and the *B-man*, who may not be a crew chief at all, but rather an avionics specialist or a weapons loader). Make sure your flyers are showing an appropriate sense of gratitude for the opportunity to borrow the airplane for an hour or two. Taking an extra moment to explain to the folks on the flight line where you are going and what kind of mission you are flying helps connect them better to the overall mission of the squadron. Nurturing those kinds of relationships may seem *way down in the weeds* at first, but they are critical to building and sustaining a culture of cooperation.

Summary

Commanding a flying squadron really is the job of a lifetime. Despite the new and unfamiliar challenges you face, the satisfaction you will feel is almost indescribable. If you are able to firmly establish a culture of cooperation in your squadron, you will reap enormous benefits. You will provide a better prepared, more combat-capable squadron to the Air Force, and you will have the pleasure of leading a cohesive, motivated group focused on common goals. And on the day you relinquish the guidon, you can take pride in knowing that you are handing over not just a good squadron but a great one.

Notes

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3. Gen Merrill A. McPeak, *Selected Works 1990-1994*, Maxwell AFB, Alabama: Air University Press, 1995, 106.
4. Maj Gen Perry M. Smith (Ret) includes technical competence as one of 30 key fundamentals that form his basis for leadership in all types of organizations. See Smith, “Rules and Tools for Leaders,” Avery Publishing: New York, 1998, 6.
5. Dodson, et al, 45-46.
6. Author’s phone conversation with Col David Nakayama, Deputy Director for Logistics, United States Air Forces in Europe, 10 Jan 02.
7. James M. Smith, “Air Force Culture and Cohesion: Building an Air and Space Force for the Twenty-First Century, *Air Power Journal*, Fall 98, 40.
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Total Mobility Flow: A Post-Kosovo Role for the DIRMOBFOR

There is no question that decreased airlift capability and forward-operating bases pose a challenge to the operational commanders. Innovation and increased discipline in enforcing current doctrine could ease their concern. The following recommendations are worthy of exploration:

- Designate a single joint force commander, when possible, to command a major operation. The joint force commander's role as a single point of contact would allow the director of mobility forces (DIRMOBFOR) to prioritize and apportion limited airlift assets. He does this by supporting the commanders' airlift requirements on a particular day and on a specific mission specified by the joint force commander through the Joint Force Air Component Command (JFACC).
- Make the director of mobility forces and JFACC inseparable. Collocation of JFACC and the director of mobility forces under one roof should be pursued whenever feasible to optimize and simplify working relationships. A total reliance on a reachback capability approach lacks the human touch that works well when working under the same roof, rather than communicating via electrons across the pond.
- Educate and train warfighters in the strategic mobility triad. The fusion of airlift, sealift, and prepositioning elements produces an effective lift capability for the operational commanders. Not everyone can be *first in line* for airlift.
- Expand the DIRMOBFOR's role to become the total mobility flowmaster. This expanded role should allow the commander in chief to enhance force buildup and closure because it would maximize use of all the strategic mobility triad elements.

After a half century of airlift, the possibility of misapplication still lurks. Operation Allied Force nearly caused the airlift system to reach its culminating point in a relatively minor conflict. A team effort from the participants averted this potential downfall. The DIRMOBFOR's utility to the operational commanders can be achieved by properly applying a unity of effort and command principles. The concept of *one boss, one team, and one mission* will streamline and synchronize airlift support. Linking the JFACC and director of mobility forces in the air operations center would effectively match limited assets against unlimited requirements. Educating and training airlift users on the viability of the entire strategic mobility triad may help ease airlift operations tempo.

Allied Force's experience confirmed that all elements of the strategic mobility triad were not fully engaged because there was no single mobility flowmaster dedicated to integrate them into a coherent, agile, and responsive system. In short, there was no DIRMOBFOR-like model for sealift and prepositioning similar to the airlift piece.

Clearly, a commander in chief needs a director of mobility forces who can effectively leverage not only the airlift piece but also the full spectrum of the strategic mobility triad. This expanded role should provide the commander in chief another tool to enhance force buildup and closure capability in the future.

Colonel Nonie Cabana, USAF

There has been growing concern that filling government positions with contractors, or even once-military jobs with government or civilian contractors, may put military readiness at risk.

Promise of A-76

does cost efficiency translate to readiness?

Major Judianna Murray, USAF

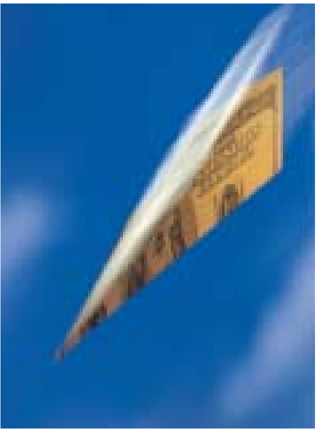
During the last decade, the DoD has placed increased emphasis on outsourcing through the A-76 process. In 1998, the department announced the opening of 229,000 positions for study to increase to 237,000 by fiscal year 2005.

Introduction

The purpose of the department's initiative is to sustain or improve readiness, generate savings for modernization, and improve the quality and efficiency of support to the warfighters.

—DoD Report, "Improving the Combat Edge Through Outsourcing," March 1996

In the post-Cold War era, the Department of Defense (DoD) is challenged with sustaining readiness for increased operational requirements around the globe. Suffering the effects of a dwindling budget and an associated personnel drawdown, the armed services have faced these global commitments with a smaller force, resulting in a high operational tempo. Long hours and high deployment rates have become the norm for many service men and women. The strong American economy of the 1990s made it even more difficult for DoD to compete with the private sector to retain the high-quality personnel needed to keep today's technology-dependent military at the necessary level of readiness. To keep pace with the technological modernization and accompanying workforce needed to maintain that level of readiness, the DoD has been pushed



A DoD report, released in March 1996, stated its three major post-Cold War challenges were readiness, quality of life, and modernization.

more than ever before to dramatically improve its cost efficiency. The answer that it has found to reduce spending has been a renewed emphasis on outsourcing and privatizing many support services. Outsourcing and privatization are terms that have come to be used almost interchangeably with one another. For the purposes of this article, outsourcing is defined as "the transfer of a function previously performed in-house to an outside provider [while] privatization is a subset of outsourcing which involves the transfer or sale of government assets to the private sector."[1] Since 1966, the Office of Management and Budget (OMB) has provided outsourcing guidance to government agencies through its Circular A-76, *Performance of Commercial Activities.* OMB Circular A-76 provides the guidelines used to determine whether or not a government function should be outsourced through cost-comparison analysis studies. These studies have come to be known as A-76 studies with the whole government outsourcing process often referred to as the A-76 process. The process allows for competition between the government and private sector businesses to find the most cost-efficient way to conduct business. The DoD's goal is to create the cost savings needed to fund the retention and modernization programs that have been hard hit since the end of the Cold War, while maintaining force readiness.[2]

Problem Significance

During the last decade, the DoD has placed increased emphasis on outsourcing through the A-76 process. In 1998, the department announced the opening of 229,000 positions for study to increase to 237,000 by fiscal year 2005.[3] The number of positions and timeframes for study have varied through this period with current plans for study standing at 183,000 jobs between fiscal years 1997 and 2007.[4] As the number of support functions opened up for study has increased, the DoD has outsourced positions closer and closer to its core competencies and mission-essential positions. There has been growing concern that filling government positions with contractors, or even once-military jobs with government or civilian contractors, may put military readiness at risk. While any positions identified as mission-essential are exempt from being opened to A-76 studies themselves, there have been an ever-increasing number of jobs once considered mission-essential now being coded otherwise, such as operations support functions, including base operations and weather flights.[5] The concern is that any unit or service as an interdependent organization will be affected by changes to any of its parts. The Air Force, for instance, has outsourced functions such as depot maintenance and weather services, which both play a direct role in the mission success of the warfighter.

A DoD report, released in March 1996, stated its three major post-Cold War challenges were readiness, quality of life, and modernization. These three challenges were identified as being interdependent and all key to future defense success. Readiness was singled out as the department's highest priority. Modernization was named as an imperative for readiness, while readiness depends on the retention of quality personnel. Retention, in turn, relies on quality of life, and quality of life requires money, as does modernization.[6] With budget cuts and increased operations requirements, even more improvements to quality of life are necessary to retain quality people. The dilemma lies in funding modernization and quality of life in spite of a lower budget. The DoD's answer, as stated above, lies in savings through cost efficiency. The 1996 report says, "The DoD can meet these challenges today and free up the additional resources required for modernization in the future by managing its internal operations, particularly its support activities, more efficiently."[7] It plans to do this primarily by outsourcing through the A-76 process.

But the question remains, is the DoD looking beyond the goal of generating savings from A-76 to what impact might be felt by the renewed emphasis on outsourcing and the restructuring of the professional relationships within the military that results from it? The previous *National Military Strategy and Quadrennial Defense Review* (QDR) called for the military to maintain readiness to conduct two major theater war operations. The 2001 QDR calls for a similar requirement with the additional burdens of homeland defense. Now we are engaged in ongoing operations in the *War on Terrorism*. There is no indication

There is no indication or any reason to believe the operations tempo will decrease in the foreseeable future. On the contrary, these are times that may require even greater effort from DoD personnel.

or any reason to believe the operations tempo will decrease in the foreseeable future. On the contrary, these are times that may require even greater effort from DoD personnel. There may be little lead time for mobilization or surge-production capability. There may be a requirement for rapid transportation, tailored and flexible maintenance support, and greater reliance on private sector suppliers. War will now be technology intensive—victory will require dominating flows of information and communication. Yet, have cost savings produced by the A-76 program been used to modernize our forces or improve quality of life? Have modernization and quality-of-life improvements resulted in the retention of quality personnel? Will an increasingly government civilian and civilian contractor force be committed enough during unpredictable times to work the extra hours or accomplish the unforeseen work? Will these unpredictable times result in money lost to paying contractors overtime or for unforeseen mission-essential tasks that are not included in a contract?

Without adequate answers to these questions, the DoD will not have a true measure of the success or failure of its outsourcing efforts. At the same time, it is clear that the DoD cannot afford, in either economic or military terms, to perform all its support functions without drawing on the competitive forces that the private sector brings with it. A balance must be found to ensure that the United States will maintain the highest state of readiness possible.

Why Outsourcing?

> *It is the general policy of the Federal Government that it will not start or carry on any commercial activity to provide a service or product for its own use if such a product or service can be procured from private enterprise through ordinary business channels.*

—Budget Bulletin 55-4, January 1955

Private Sector Applications

The benefits of outsourcing and competition are apparent every day in our national economy. Many companies report that outsourcing produces cost efficiency. This enables firms to focus on their core competencies; improve service quality, responsiveness, and agility; obtain access to new technologies; and employ more efficient business practices. Over the last two decades, competitive forces in the private sector have revolutionized how companies obtain services. Whole new industries and companies have been formed to meet the demand for specialized services across a range of functions, to include aircraft and ship maintenance, inventory management, and accounting and finance.[8]

Several studies have shown the success of outsourcing for America's top companies. A 1994 study conducted by Pitney-Bowes Management Services found that 77 percent of the 100 Fortune 500 firms surveyed outsourced some aspect of their business support services. Another 1994 study, conducted by KPMG-Peat Marwick of 309 Fortune 1000 companies, found that 48 percent outsourced warehousing functions. Yet another study conducted by the Olsten Corporation of 400 firms found that 45 percent outsourced payroll management functions. Individual companies in the private sector also show the prevalence of outsourcing. Canon guarantees photocopier replacement within 24 hours but outsources the delivery of this service. Chrysler manufactures engines, transmissions, and exterior body skins internally but outsources the remaining 70 percent of its final product. Similar examples exist in every successful American industry. Many state and local governments also take advantage of the benefits of competition. Chicago, Indianapolis, Los Angeles, Philadelphia, and San Francisco, to name a few, have all used competitive outsourcing to improve services and lower costs.[9] There is no question among today's top companies that outsourcing is a best business practice that is necessary to stay competitive and achieve success in the current environment.

Several studies have shown the success of outsourcing for America's top companies.

Historical Background in the Federal Government

The practice of competing out government work to be done by private companies is not a new idea. During the Eisenhower administration, the government issued Budget Bulletin 55-4 to stimulate private sector growth during the transition from the post-World War II and Korean War economy that saw a dramatic military drawdown. The

The DoD drew the line at outsourcing only nonmission-essential positions, coded as such by each military service's personnel and manpower directorates.

policy stated that the government would procure any necessary goods and services from the private sector, when available, rather than creating those services for its own use.[10] This policy has formed the foundation for government cost-savings efforts throughout the years since.

A-76 Implementation

OMB first published its Circular A-76, *Performance of Commercial Activities,* in March 1966 with subsequent updates issued in 1979 and 1983. This OMB circular provided the guidelines for outsourcing government functions and continued the government's preference of relying on private enterprise to supply its commercial needs.[11] The A-76 program also allows the government provider to compete with private companies for the commercial work being competed by allowing government agencies to reengineer their activities to form a most efficient organization (MEO).[12] In March 1996, OMB revised the A-76 process to provide for streamlined cost comparisons, fixed overhead rates for in-house cost estimates, and several technical changes to standardize work to be able to compare like units to one another.[13]

The Growth of Competitive Sourcing

Spurred by the Federal Acquisition Streamlining Act of 1994, the Deputy Secretary of Defense directed defense agencies and the military services to make outsourcing of support activities a priority to reduce operating costs and free up funds to support other priority needs.[14] This effort was subsequently incorporated under the Secretary of Defense's Defense Reform Initiative in 1996, with the program becoming known as competitive sourcing. The Federal Acquisition Reform Act of 1996, DoD Directive 5000.1, and DoD Regulation 5000.2 were issued to further enable significant changes to the department's procurement of goods and services. Along with these initiatives, a systematic review of support operations was called for to determine where competitive forces could improve overall performance at a lower cost.

The DoD drew the line at outsourcing only nonmission-essential positions, coded as such by each military service's personnel and manpower directorates.[15] Services will not consider outsourcing activities that constitute core capabilities. Nonmission-essential functions will be considered only if the private sector can improve performance or lower costs in the context of long-term competition. Also, a competitive commercial market must exist for the activity so that there is an incentive for continuous service improvement.[26] The result of any outsourcing outcome must be the best value for the government and, therefore, the US taxpayer.

Outsourcing efforts under the A-76 process quickly drew criticism.

The competitive sourcing view focused on six areas: materiel management (provisioning, cataloging, requirements determination, asset management, distribution, and disposal), base commercial activities (functions necessary to support, operate, and maintain DoD installations—such as facilities maintenance, food services, local transportation, and vehicle maintenance), depot maintenance, finance and accounting, education and training (increasing technology demands for training), and data centers.[17]

Outsourcing efforts under the A-76 process quickly drew criticism, however. The DoD became concerned that the process was more costly to implement than expected and more time-consuming than the system could afford. Typically, A-76 studies took up to 24 months to complete a simple cost comparison and 48 for a more complex one. Such cost-comparison efforts undertaken in the private sector, by contrast, only take about 12 months.[18] These long time lines proved to be a strong disincentive for government managers who were often reluctant to dedicate resources to an A-76 cost comparison that could cost hundreds of thousands of dollars when the benefits would not be realized until years later. Skepticism and delays in the outsourcing decisionmaking process made it difficult for the DoD to achieve its cost-savings objectives.

Strategic Sourcing

In April 2000, the DoD issued guidance with new tactics for outsourcing. Under the title *strategic sourcing*, the government is no longer strictly bound to the constraints of the A-76 process. The tactics include eliminating jobs, consolidating operations, and privatizing work. This gives the services more latitude for reaching their savings goal of roughly $11B.[19] The money from these savings was to be directed toward new weapons and readiness programs.

While the guidance primarily seeks to streamline the A-76 process, it also allows agencies and services to circumvent A-76 job competitions altogether by seeking new ways to cut costs.

This latest guidance was issued by Jacques Gansler, Under Secretary of Defense for Acquisitions, Technology and Logistics. In a memorandum to the service components and defense agencies, Gansler stated, "Strategic sourcing is a means to achieve even greater savings."[20] The strategic sourcing approach encompasses all functions or activities that could be reengineered or consolidated regardless of whether they are inherently governmental, military-essential, or commercial activities. Strategic sourcing releases the exemption from outsourcing competition of thousands of defense jobs such as depot workers, firefighters, and security guards among many other inherently governmental mission-essential positions.

While the guidance primarily seeks to streamline the A-76 process, it also allows agencies and the services to circumvent A-76 job competitions altogether by seeking new ways to cut costs. The plan for strategic sourcing includes eliminating obsolete business and administrative practices, consolidating functions or activities, reengineering or reorganizing functions or activities, adopting commercial business practices, and privatizing work by issuing waivers of A-76 competitions.[21] By giving the Services an avenue aside from the A-76 process, the time and money needed for A-76 studies could be reduced by competing fewer jobs and turning attention toward producing cost efficiency by reengineering other government functions.

Under the A-76 program, competition between federal employees and commercial companies is required before most federal work can be outsourced, with the jobs going to the lowest bidder. Gansler admitted that industry and government workers had expressed concerns about the fairness of A-76 competitions, but he stressed that A-76 competitions would still be the dominant factor in DoD reform efforts. He emphasized that strategic sourcing "should not be interpreted as an avoidance of, alternative to, or a retreat from, A-76 cost comparisons."[22] However outsourcing experts and officials remained skeptical that defense organizations would overlook the opportunity that the new guidelines provided as a way to avoid the often-cumbersome A-76 process.

Without the strategic sourcing approach to outsourcing, it does not seem likely that the Pentagon will reach its $11B savings goal by 2007. With strategic sourcing, the DoD would go from being able to study roughly 300,000 positions under competitive sourcing to now being able to look at all 900,000 jobs in the department, which, they believe, could create more savings and outsourcing.[23]

The Navy pioneered the strategic-sourcing concept and was the first to win Pentagon approval for implementing it. The Navy's approach called for opening 56,000 jobs to A-76 competitions and privatizing and eliminating or reorganizing 40,000 additional jobs to meet its $5B goal. Originally, the Navy had planned to open 77,000 jobs to A-76 competition study and would have fallen short of its cost-savings goal.

Thus far, strategic sourcing has been slow to be implemented DoD-wide. Plans for study of positions have fluctuated greatly over the last several years and, according to a recent Government Accounting Office (GAO) report, are likely to continue to do so.[24] Despite the inherent difficulties in implementing the A-76 process and widespread criticism and skepticism, the DoD remains committed to outsourcing as the best avenue for achieving the kind of savings needed to turn toward modernization and general defense-wide progress and improvement.

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Status

The April 2000 guidance for strategic sourcing also addressed deficiencies in the tracking and evaluation of outsourcing results. It called for the Pentagon to develop a computerized system to audit and track the effectiveness of DoD outsourcing programs to show whether they are achieving savings and enhancing performance. Part of the implementation of this system is the SHARE A-76 online Web site, which serves as a clearinghouse for A-76 competition information, policy guidance and changes, and lessons learned from A-76 participants and process managers. Audits to evaluate specific performance measurements are now required within a year after completion of a job competition.[25]

Outsourcing efforts have continued to be implemented within the DoD during the last 2 years, with periodic changes to the number of positions to be studied and timeframes for the studies in each category (strategic sourcing, reengineering, or A-76 job competition).

Congress enacted Section 832 of the National Defense Authorization Act for FY01, which required a panel of experts to be convened to study outsourcing policies and procedures.

Controversy and concerns have continued to surround the program. As a result, Congress enacted Section 832 of the National Defense Authorization Act for Fiscal Year (FY) 2001, which required a panel of experts to be convened to study outsourcing policies and procedures. After completion of field hearings, the panel, known as the Commercial Activities Panel, has been working to:

> …(1) gather background information on sourcing trends and challenges, (2) identify sourcing principles and criteria, (3) consider A-76 and other sourcing processes to assess what's working and what's not, and (4) assess alternatives to the current sourcing processes.[26]

The results of the Commercial Activities Panel should provide a clearer picture concerning the effectiveness of outsourcing program implementation and the extent of savings realized from these efforts. Recent reports and audits do show cost savings are being achieved, but difficulty in maintaining reliable estimates has cast doubt on the accuracy of reported savings figures.

A-76 Cost Savings

> *Defense needs to know if there are true savings from outsourcing. All we have now is a promise from contractors that they will do the work right.*
>
> **—Wiley Pearson, Defense Analyst, American Federation of Government Employees, May 2000**

As stated previously, a dwindling budget and ever-increasing operational demands have made seeking avenues for cost efficiency an imperative. The DoD believes experience has shown that competition and outsourcing have resulted in significant savings and, they would argue, increased readiness for each of the military services.

In 1997, the department significantly increased the number of functions that would be competed by more than three times that of any year in the previous two decades. Based on historical experience, it expected to save approximately $6B over the following 5 years, with annual recurring savings thereafter of $2.5B as a result of these studies.[27]

According to DoD cost comparisons between 1978 and 1994, the results of outsourcing were reported to produce savings of about $1.5B a year. On the average, these competitions were reported to have reduced annual operation costs by 31 percent (Table 1). Of these competitions, the private sector and government activities each won about half. No matter the outcome, the end result to competition should result in greater productivity due to the in-place support function being required to reengineer and become an MEO.

As a result of the A-76 emphasis, the DoD currently outsources approximately 25 percent of base commercial activities, 28 percent depot maintenance, 10 percent finance and accounting, 70 percent Army aviation training, 45 percent surplus property disposal, 33 percent parts distribution, as well as substantial portions of other functions.[29] Virtually every support function within the department is carried out somewhere by the private sector.

These savings should be looked at in the context of current defense figures with a force structure 30 percent smaller than the 1980s and a budget about 60 percent (in real terms) of its 1985 peak. These figures are based on the FY97 budget of $243B. In FY96, the DoD spent an estimated $93B on support operations and maintenance, which represented a sizable portion of the defense budget. The procurement budget declined about 68 percent (in real terms) between 1985 and 1996 with the 1996 procurement budget standing at $43B.[30] To maintain readiness in the face of these declines, the DoD significantly reduced infrastructure costs through the base realignment and closure process and initiated thorough reform of the

	Competitions Completed	Average Annual Savings ($M)	Percent Savings
Army	510	$470	27
Air Force	733	$560	36
Marine Corps	39	$23	34
Navy	806	$411	30
Defense Agencies	50	$13	28
Total	2,138	$1,478	31

Table 1. A-76 Cost Comparisons: 1978-1994[28]

Promise of A-76: Does Efficiency Translate to Readiness?

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The GAO currently reports that, while there are still some misgivings with projected A-76 savings estimates, results of A-76 competitions are producing savings in the long run.

acquisition process. With its eye on money spent on support functions, the DoD set out to produce savings, primarily through reducing personnel costs, by outsourcing those functions.

Between 1996 and 1999, DoD announced a massive effort to compete more than 200,000 positions with an ambitious goal of saving anywhere from $7 to $12B annually by 2002.[31] However, on the heels of criticism of the often slow and costly A-76 process and skepticism about whether these savings could actually be achieved, the number of jobs to undergo A-76 study has dropped to 183,000 to be competed between 1997 and 2007. This number included 135,000 jobs between 1997 and 2001 and 48,000 between FY02 and FY07. It also projects that 144,000 additional positions will be studied under strategic sourcing outside of A-76.[32]

The GAO currently reports that, while there are still some misgivings with projected A-76 savings estimates, results of A-76 competitions are producing savings in the long run. Primarily, these savings are being seen by the reduction of positions needed to perform an activity that results from competing a function to the lowest bid. This was true whether the in-house government organization or a private sector bid won the competition. In December 2000, the GAO reported DoD cost reductions of approximately 39 percent, yielding an estimated $290M savings in FY99.[33] At the same time, however, they stressed difficulty with being able to quantify the savings for the following reasons:

- An initial lack of DoD guidance on calculating costs, baseline costs were sometimes calculated on the basis of average salaries, and authorized personnel levels rather than on actual numbers.
- DoD savings estimates that did not take into consideration the costs of conducting the studies and implementing the results, which, of course, must be offset before net savings begin to accrue.
- Significant limitations in the database DoD used to calculate savings.
- Difficulty in assessing savings over time as workload requirements or missions change, affecting program costs and the baseline from which savings were initially calculated.[34]

The report goes on to say that it appears the DoD is realizing savings overall but, because of difficulties with the savings calculation, some data show an overestimation of savings while others might be underestimated.[35] Another source reports that defense estimates of the cost of outsourcing are accurate only within about 20 percent.[36]

The bulk of DoD outsourcing through the A-76 program has taken place only in the last few years. Although the department has been somewhat slow to implement an accurate system to track its savings from outsourcing, it still seems fairly certain that savings are being produced.[37] Perhaps, only time will tell just how much the DoD has saved through outsourcing. Whether or not these savings are being put into modernization and retention programs is yet another question.

Military readiness is an elusive term based on a number of ever-changing factors.

Readiness Impacts

> *If you lose your readiness, you lose the people. If you lose the people, you lose it all, for a generation.*
>
> **—General Michael E. Ryan, Air Force Chief of Staff, September 2001**

Military readiness is an elusive term based on a number of ever-changing factors. This being the case, it is difficult to pin down readiness into quantifiable terms. In general, readiness is understood as the military capability to maintain sufficient forces, equipment, training, logistics, professional development, and financial resources to carry out National Military Strategy objectives. While the DoD does not specifically track readiness impacts that can be directly linked to the A-76 program, there are many examples that show instances where readiness has been sacrificed because of A-76 outsourcing and other cost-savings programs.

At many bases affected by outsourcing, the impact to readiness has been felt mainly as a result of losing positions, leaving fewer people to shoulder the workload. In an effort to reduce operating costs to become an MEO and prepare for A-76 study, activity-based costing estimates have, by and large, failed to take into account the additional duties that military personnel are tasked with, aside from the duties assigned to their particular position. What many units that have been through the A-76 process are finding is the personnel requirements produced by creating an MEO are only sufficient for

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normal operations. Whenever a contingency tasking or additional duty enters the picture, someone must do overtime. For units with military members, this extra time is spread among fewer workers left behind by strategic sourcing or A-76 efforts. When only contractors are involved, the Air Force must foot the bill for any additional duties not specifically written into the contract or suffer the consequences of not being done. The following is just one example of the above effects of the A-76 program.

At Maxwell AFB, Alabama, the A-76 process dragged on for several years with the job competition for many base support functions finally being won by DynCorp, a private sector contractor. DynCorp assumed responsibility for the base's 42d Communications Squadron, which provides critical computer and communications support to many base agencies and most functions of the 42d Operations Support Squadron (OSS) in 2002.[38] The uncertainty of the outcome of the job competition for such a long period caused personnel shortages as positions that were vacated by routine military personnel relocation were left unfilled.

In addition to preparing for the A-76 study, the 42 OSS Weather Flight was also going through the Air Force-wide reengineering of weather services, a strategic sourcing corollary to the A-76 program. In a span of 4 years, the weather shop at Maxwell has reduced its manning from 23 to 6 positions.[39] According to the 42 OSS Commander, all the above aspects of going through the A-76 process have already cost his unit many hours of extra duty.[40]

The Air Command and Staff College (ACSC) technology office, which provides computer support for more than 700 staff and students, has also been affected by the A-76 process at Maxwell AFB. The DynCorp transition will eventually replace all the office's employees. The chief of ACSC Technology believes contractor ownership of his unit's computer support office will reduce the flexibility that the college has with its current military manning.[50] When security situations caused his office to shut down the unit server and carry out regulatory procedures before bringing personal computers back online, technology personnel worked around the clock for nearly 3 days. He believes with a contractor performing this function a bigger impact to the unit's mission (officer training) might be felt as well as there being potential cost to the Air Force for any overtime the contractor performs that is not specifically covered by contract.[41]

The ACSC technology office has also been tasked with providing personnel on a limited basis to serve as base gate security guards since the 11 September terrorist attacks. This additional duty further impacts its workload and is an example of the kind of contingency military members often face. With contractors taking over many currently military positions on bases around the country, it will fall on the mission-essential military members remaining to perform this type of unforeseen tasking for which a contractor is not qualified or is not on contract to perform. It is inevitable that such additional taskings impact mission readiness.

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The above-mentioned units at Maxwell support training units and are not on mobility status. However, a wide range of bases Air Force-wide have been affected by the A-76 program, to include those that support combat-ready units.

Although DoD proponents of the A-76 process repeatedly tout increased mission readiness as a direct result produced by outsourcing cost savings, there does not appear to be any system in place to measure a relationship between the two or to show how savings have been used to improve readiness.

Since A-76 is mandated to be applied only to nonmission-essential functions to specifically avoid causing a negative impact to readiness, the DoD seems to consider such readiness impacts from the A-76 program to be a nonissue with its primary focus being on cost savings. There have, however, been concerns raised from both inside and outside the military community concerning a link between the increased emphasis on outsourcing through the A-76 program and recent military readiness indicators.

Equipment indicators show Air Force readiness rates dropped throughout the 1990s.[42] According to Air Force Chief of Staff (CSAF) General Michael E. Ryan, the aggregate nonmission-capable (NMC) rate increased from about 17 percent in 1991 to 25 percent in 1998, which represents a 53-percent growth in the NMC rate over those

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7 years. Cannibalization rates increased 58 percent from 1995 to 1998, further illustrating the lack of available aircraft parts needed to keep planes in the air. Cannibalized parts are those taken from one aircraft to fix another. In 1998, General Ryan issued a special interest commanders' notice to airmen on readiness, highlighting an overall major unit-readiness drop of 19 percent from 1996 with continental United States base readiness falling an astounding 58 percent over the same period. In January 1999, the general reported an additional drop in stateside readiness of 28 percent from the previous year.[43]

On the personnel readiness side, recruitment and retention have both been on a downslide, prompting the Air Force to implement programs for reenlistment bonuses and other pay incentives to entice highly trained personnel to stay in the service despite opportunities for civilian employment soaring during the last decade. While neither of these indicators necessarily shows a direct result from outsourcing efforts, they do reflect the climate of the Air Force during a period when outsourcing has been emphasized and its effects felt by most personnel.

In a September 2001 interview as he was leaving his position as Air Force Chief of Staff, Ryan stated that throughout his tenure as Chief, "We emphasized people …[and] readiness investment big time, at the expense of modernization and infrastructure."[44] These remarks indicate that contrary to the DoD's promise of cost savings going toward modernization and retention, the savings have not been enough to effectively increase readiness, let alone be turned toward the goal of modernization.

The question remains whether or not there is a direct relationship between the DoD's outsourcing programs and military readiness during this same period. With no data to support such a relationship, we can only rely on anecdotal evidence. Perhaps in response to concern regarding the perception of outsourcing impacts, the 2002 CSAF Survey contains a special interest item on competitive sourcing. The survey asks personnel to rate the following six statements concerning the A-76 process, on a scale from strongly disagree to strongly agree.

Functions that have been through the A-76 process and remained in house are performing better than before the study.

Functions that have been through the A-76 process and were contracted or outsourced are performing better than the in-house force did it before the study.

The A-76 competitive sourcing program limits my opportunities for career progression.

The A-76 competitive sourcing program increases my desire to seek employment outside the Air Force.

Two objectives of the A-76 competitive sourcing are:

- Free up manpower so those resources will be dedicated to warfighting missions.
- Reallocate the saved manpower funds to optimally support mission critical programs (for example, military pay and benefits and force modernization).

With these objectives in mind, please comment on the following:

The A-76 competitive sourcing program saves manpower so that those resources will be dedicated to warfighting missions.

The A-76 competitive sourcing program is saving money for the Air Force.[45]

These clearly reflect a high-level concern about how Air Force personnel perceive the A-76 program and how it has directly affected morale and retention decisions. The inference can be made that Air Force leadership is at least aware of the controversial effectiveness of A-76 programs and their potential impacts on mission readiness. It also suggests the Air Force does not have solid answers to the A-76 program effectiveness question itself.

In an era of increased operational tempo because of personnel drawdowns and increased taskings, the additional loss of manpower from A-76 must affect the workload, morale, and productivity of a unit. As an interdependent organization, it could be argued that any effect on the support functions of mission-essential units would impact the ability of the unit to maintain readiness to perform its overall mission.

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Conclusions

We strongly believe that the department must establish a process to track how effectively these programs are achieving savings and enhancing performance.

—Jacques Gansler, Under Secretary of Defense for Acquisition, Technology, and Logistics, April 2000

Promise of A-76: Does Efficiency Translate to Readiness?

In an era of increased operational tempo because of personnel drawdown and increased tasking, the additional loss of manpower from A-76 must affect the workload, morale, and productivity of a unit. As an interdependent organism, it could be argued that any effect on the support functions of mission-essential units will impact the ability of the unit to maintain readiness to perform its overall mission.

Outsourcing is not a theory based on uncertain assumptions. The success experienced in the private sector, as well as by the DoD, consistently demonstrates how the competitive forces of outsourcing can generate cost savings and improve performance. Through its outsourcing initiatives, the DoD has begun a long-term effort to streamline its support functions. The success of the department initiatives should certainly help determine how well it supports the warfighters tomorrow.

Actual cost comparison data show the DoD is achieving its objective of saving money through outsourcing. These savings, however, are often at the expense of losing positions and, therefore, personnel. This research has shown that the workload previously shouldered by personnel in these lost positions is often shifted elsewhere in an organization, rather than being eliminated by more efficient business practices. Where contractors have replaced government personnel, the load of inherently military additional duties is further compounded for remaining military personnel. As a result, the already high operational tempo experienced throughout the Services continues to increase, placing more stress on the Air Force's ability to retain personnel and maintain readiness. The windfall for modernization efforts envisioned by the DoD in 1996 clearly has not materialized in the Air Force as it has been forced to focus on simply maintaining readiness to meet its increased workload.

This research was unable to discover any data kept by the DoD or any of its service components regarding A-76 program impacts to unit readiness or any attempt to address the possibility of a link between the two. However, there is clearly a tie between morale, retention, and increased workload among support functions affected by A-76 outsourcing and other streamlining and reduction programs to the mission-essential personnel that these functions support. This link indicates that the effects of the A-76 program are among the factors that impact mission readiness.

While the DoD has come a long way toward streamlining its A-76 process, there is still plenty of room for improvement for the process to become as productive as private sector outsourcing has become. The implementation of strategic sourcing, collecting data on job competition effectiveness by timely auditing, and sharing information on the SHARE A-76 Web site have all contributed to process improvement. There is no doubt that the proverbial learning curve has been steep, and the growing pains have been strong as the military has made its way through unfamiliar nongovernmental territory. Outsourcing has not been an easy fit with traditional military operations. Some would argue that the very nature of military operations makes outsourcing efforts inherently a bad idea if the DoD is to maintain the readiness that is of vital importance to national security. However, like it or not, the DoD must be held accountable to the American public for its spending the same as any other government agency. Until the DoD can perform at a level of efficiency more akin to the private sector, it is doubtful its vision of modernization and mission-readiness improvements through outsourcing can be achieved.

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Recommendations

To reap the benefits of outsourcing, the DoD must be willing to make its processes more like those of the private sector, where possible. Despite its efforts, the government still supports redundancy and outmoded ways of doing business in many areas. However, there is a fine line between bringing in new practices and negatively affecting morale and readiness through sweeping changes. The transition for institutional change of this magnitude must be managed with great care.

The first step, though, is to gain an understanding of where private sector processes can be employed effectively by studying the impacts of current efforts. Both the Commercial Activities Panel, for the entire DoD, and the CSAF Survey, specifically for the Air Force, should provide a wealth of information concerning outsourcing effectiveness. Further research and comprehensive data collection to track the input and output of every function that is currently implementing, or scheduled to implement, outsourcing programs of any kind would also greatly benefit the DoD by providing the metrics necessary to evaluate where outsourcing works and where it does not.

There are also several avenues that the Air Force should consider to alleviate the problems stemming from the

To reap the benefits of outsourcing, the DoD must be willing to make its processes more like those of the private sector, where possible. Despite its efforts, the government still supports redundancy and outmoded ways of doing business in many areas.

increased workload on military members created by force reductions and contractor restrictions. Great benefit could be derived from the extensive use of manpower surveys to track personnel workload. The surveys can determine how much time personnel spend on additional duties and how that time affects performance of core mission duties or requires them to work extended hours with increased operational tempo. Where possible, the Air Force and individual units should consider eliminating some traditional, yet nonmission-essential, additional duties. A review of manpower surveys will help units to find the additional duties that can be eliminated.

Besides the impact of a static amount of additional duties spread among fewer military employees, manpower surveys will also show the additional workload created for mission-essential personnel, whether a function remains in-house by MEO force reduction or goes to a contractor. Extra time and money charged by a contractor need to be compared to the cost of keeping a function in house through frequent audits. Contracts need to be written to allow the audit process to recompete functions when contractors are unable to perform effectively after winning an A-76 job competition.

Outsourcing effects on morale and retention will be seen with the CSAF Survey. The Air Force can gain critical insight from participants' responses to the questions concerning outsourcing effectiveness. The results of this portion of the survey should be compared to actual unit performance and readiness indicators following an A-76 competition to track the effects that outsourcing efforts are having on the force as an integrated organism. With this information in hand, the department will be able to better evaluate the success of its current implementation of the A-76 program. Survey results can be obtained through the Air Force Manpower and Innovation Agency Web site.[57]

The A-76 process has many areas in need of further investigation. While this research was limited in scope to interviews conducted at Maxwell AFB as a supplement to current A-76 program literature, further research to survey a variety of bases and functions affected by the A-76 process will provide a broader spectrum of data to show Air Force-wide readiness impacts.

With the 2002 CSAF Survey results as a beginning point, linked to actual performance and readiness reports, future research should look for success stories as well as more evidence, such as that experienced and foreseen at Maxwell, of added workload, placing readiness at risk. By collecting and analyzing these data, Air Force leaders working with A-76 program managers will be able to see the overall effects of outsourcing on unit productivity and readiness. Identification of functions that have successfully transitioned to cost efficiency and increased productivity can be used as benchmarks, allowing the Air Force to be smarter in the implementation of future outsourcing efforts.

The A-76 process has many areas in need of further investigation.

Rather than continuing to focus primarily on cost savings, the DoD needs to consider the rest of the equation. More data need to be collected and studied to determine A-76 program impacts to warfighter readiness. Only through further research and analysis will the DoD fully know whether the benefits of its outsourcing programs, to include the A-76 process, outweigh the potential costs.

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Rather than continuing to focus primarily on cost savings, the DoD needs to consider the rest of the equation. More data need to be collected and studied to determine A-76 program impacts to warfighter readiness.

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Air Force MICAP Shipping Policies

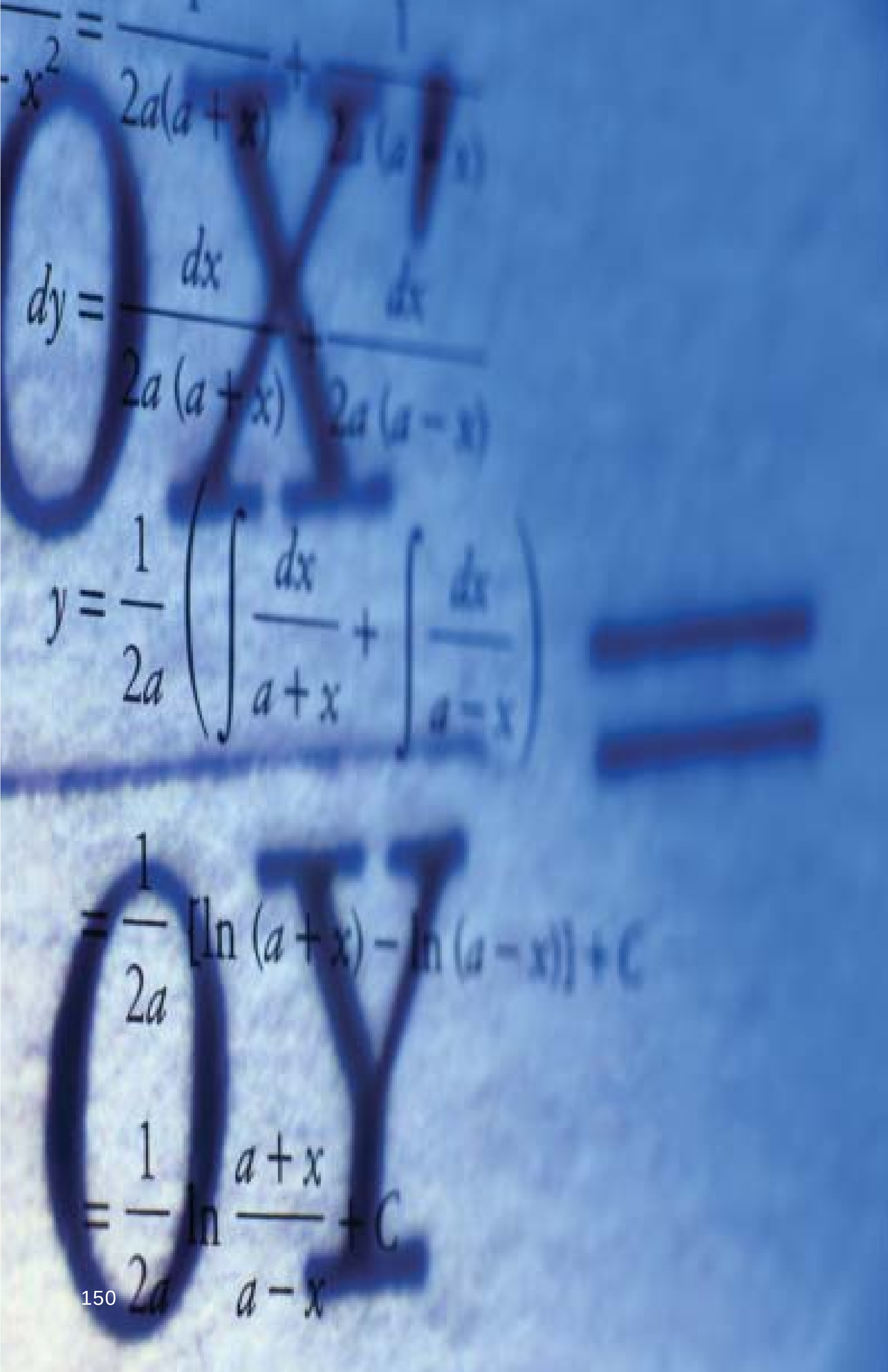
Cost savings can be realized using Roadway, as opposed to FedEx, for certain shipments, if cost of the shipment is a major criterion. From this perspective, the Air Force and the Department of Defence's (DoD) current modal and carrier choices are not optimal. Both the Air Force and DoD need to reevaluate the policies directing shipment of mission-capability (MICAP) items.

The shipping organization should use the less-than-truckload (LTL) carrier for MICAP items if the carrier's rate is less than FedEx and the LTL carrier can meet the time standards required for delivery. However, to further validate this, additional study that includes more actual MICAP shipping data may be warranted.

Overall, Roadway is a viable alternative, from a cost standpoint, to FedEx for shipping MICAP items within the continental United States and Alaska. Further, additional competition would affect rates. Rates would be reduced if the Air Force and DoD had an alternative carrier for MICAP shipments. FedEx would have to keep its rates down to the level of its competitor. This conclusion is made with the assumption that FedEx and the LTL carrier can maintain the same level of service or the same time standards between pickup and delivery. This also keeps the other express air carriers from raising their rates. The carriers in the air mode would not have an incentive to form a cartel and raise rates if another mode, such as express ground or LTL, were vying for the government's business. If the express air carriers formed a cartel, they would cut themselves out of the market for DoD express shipping needs.

Most carriers in the LTL marketplace are regionalized, as opposed to the air carriers, which are national. If DoD and the Air Force use LTL, it would increase competition between not only the competing modes but also the LTL carriers. Additionally, DoD possibly would not need to enter a contractual agreement with a national LTL carrier because of the large number of regional LTL carriers. DoD and Air Force use of LTL creates competition for business on a regional and national level. Overall, this competition will result in lower rates.

Captain Jason L. Masciulli, USAF
William A. Cunningham III, PhD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Obsolescence management has become an increasingly important issue to the Department of Defense. Concerns and studies of how to address obsolete technology can be traced back to the 1960s.

Cost-Benefit Analysis

tools for avionics parts obsolescence

Luvenia L. M. Suman

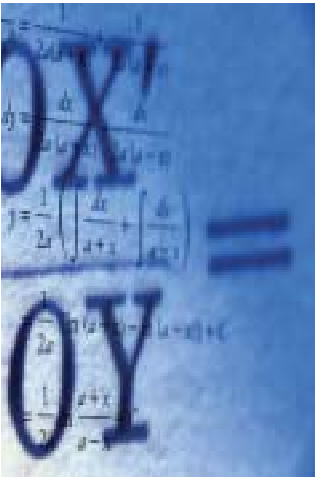
Part obsolescence does not mean the part is no longer required but refers to a component or part that the commercial market considers no longer economically feasible to manufacture.

Introduction

Obsolescence management, an ever-increasing topic in the Department of Defense (DoD), is not new. Concerns and studies of how to address obsolete technology can be traced back to the 1960s. However, the growing technology refresh rate in the commercial market has exacerbated the issues surrounding management of obsolescence. Since the service life of military systems is much longer than commercial systems, maintaining military systems when parts and components go out of production remains a sustainment challenge. Further, constrained defense funding will necessitate prudent use of limited funding to balance current systems maintenance and new systems acquisition.

Definitions

Part obsolescence does not mean that the part is no longer required but refers to a component or part that the commercial market considers no longer economically feasible to manufacture. Diminishing manufacturing sources and materiel shortages (DMSMS) is a larger category of supply concern that includes discontinued production resulting from obsolescence as well as other reasons



Today, several factors have increased the historical problems creating the need for a separate obsolescence management field.

such as rapid change in technology, foreign source competition, and federal environmental or safety requirements.[1] The terms part obsolescence and DMSMS are used interchangeably. Weapon system as used in this document includes major weapon systems such as aircraft, missiles, or tanks, as well as their internal or external subsystems such as radar-warning receivers, jamming systems, precision munitions, or chaff dispensers.

Historical Perspectives

Obsolescence management has become an increasingly important issue to the Department of Defense. Concerns and studies of how to address obsolete technology can be traced back to the 1960s as technology transitioned from vacuum tubes to solid-state transistors and then to digital electronics.[2] These earlier obsolescence concerns were normally managed under broader support concepts such as maintainability or sustainability. Today, several factors have increased the historical problems creating the need for a separate obsolescence management field. These include an increase in electronic combat technologies, the extension of weapon system service life, rapid technology advancements, and the shrinking military market.

Obsolete Parts = Electronics

As the Department of Defense continues to emphasize technology through national military operational concepts such as precision engagement and dominant maneuver, the use of electronics in military systems will continue to grow. To achieve these objectives, the Air Force uses electronic combat technologies.

Electronic combat involves actions to neutralize or destroy an enemy's electromagnetic capability and to protect friendly electromagnetic capabilities. It includes electronic warfare as well as elements of command, control, and communications; countermeasures; and suppression of enemy air defenses.[3]

While extensive research has not been performed on the narrower category of obsolescence in electronic combat systems, electronic combat technology is a subset of avionics or aviation electronics, which has been studied extensively.

Two separate studies have concluded that obsolescence is a major problem for electronic parts while obsolescence problems relating to mechanical parts are only minor.[4] In one of the studies, the author concluded, "Without exception, every DoD agency and contractor visited stated that electronic components were the greatest problem in both cost and quantity of discontinuances."[5]

The costs of these problems are revealed in the Air Force capability and budget. A national committee on aging avionics attributed a decline in the 1990s of the mission capability of Air Force aircraft from 83 percent to 73 percent to the aging aircraft fleet, particularly the aging avionics systems.[6] Also, in 1999, one-third of the Air Force's expenditures for depot-level repair of aircraft went to the support and maintenance of avionics systems, which totaled approximately $1B.[7]

Weapon System Service Life

While military weapon systems, by design, experience long service lives to recoup the cost of the investment, limited defense funding has extended service lives even longer and delayed needed weapon system modernization. "The operational lifetimes of legacy aircraft are being extended well beyond their original design lifetimes resulting in an average age of US military aircraft of 20 years."[8]

> Platforms such as the B-52 bomber, the KC-135 tanker aircraft, and the C-130 cargo plane, which were conceived in the 1940s and 1950s, for example, are expected to remain operational into the next century—giving them a service life of more than 80 years.[9]

These long service lives result in the loss of supply sources for electronic components. While the military still requires availability of electronic devices and components (some military unique) for these older weapon systems, commercial sources move on to more profitable markets with higher volumes. "From 1986 to 1996, for example, the percentage of discontinued military/aerospace electronic devices nearly doubled—from 7.5 to 13.5 percent."[10]

Rapid Technology Advances

The obsolescence problems faced in today's military environment stem not only from aging systems but also

The military services no longer control the major portion of the electronics industry and thus, have little influence over electronics manufacturers and technology refresh cycles.

from rapid changes in commercial technology. The current market demands for the latest and fastest technology result in new technology updates every 18 months to 3 years.[11] The typical life cycle of an electronic part lasts from 4 to 7 years, while development of a military weapon system can take up to 5 years with production spread over several more years.[12] As a result, new military systems such as the F-22 fighter and the B-2 bomber are also experiencing ever-increasing electronics obsolescence problems.[13] For example, "the F-22 program now budgets $50 million a year to replace 'old' avionics with new hardware and software and will have undergone four technology refresh cycles by the time the first production F-22 rolls off the line."[14] According to the F-22 program manager, "No two of the 339 aircraft that I build will be the same."[15]

Military Market Trends

The Services no longer control the major portion of the electronics industry and thus, have little influence over electronics manufacturers and technology refresh cycles. In the 1970s and early 1980s, military requirements were the principle influence over the market's technology.[16] Now, military requirements for a microelectronic device in the thousands cannot compete against commercial markets such as cell phones and personal computers that have requirements in the millions. According to the Director of the Defense Microelectronics Activity, "The entire Defense industry share of the global microelectronics market is now only about 0.3 percent so our [the military's] influence on the component manufacturers is minimal."[17]

Obsolescence Handbooks and Tools

With the growing number of obsolete parts, program and item managers are in need of tools to assist them in making timely decisions to resolve the obsolescence problem. Several automated tools designed to predict future obsolete parts early in the system's life cycle are available. While these predictive tools provide an invaluable capability to the program and item manager by identifying potential obsolescence problems early in the life cycle, increasing the time and options available for resolution, these tools do not include cost-benefit analysis of the obsolescence resolution options, which is the focus of this project. During the literature review, two models or guides relating to costs were identified that are available to assist program and item managers in making decisions to resolve obsolete parts problems and ongoing efforts to develop automated cost-benefit analysis tools.

Model or Guide

In addition to DoD and individual service directives and instructions, the Air Force, Army, and Navy have each produced a DMSMS case resolution guide to assist program and item managers in lessening or eliminating the risks caused by parts nonavailability before the weapon system is adversely affected. The Air Force guide, *Air Force Materiel Command Case Resolution Guide*, includes worksheets to compute rough-order-magnitude estimates to assist in the cost-benefit analysis.[18] This cost-benefit analysis tool will be further discussed and analyzed later in this article. Additionally, the Defense Microelectronics Activity (DMEA) as the DoD Executive Agent for DMSMS developed cost factors for various DMSMS resolutions so that DoD programs can uniformly report cost avoidance and determine the cost impact of implementing a DMSMS program.[19]

Although existing automated cost-benefit analysis tools to assist program and item managers in selecting obsolescence resolution options were not identified by review of current literature, an initiative was identified with the goal of developing automated support tools for this decision.

Tool Development Efforts

Although existing automated cost-benefit analysis tools to assist program and item managers in selecting obsolescence resolution options were not identified by review of current literature, an initiative was identified with the goal of developing automated support tools for this decision. The Air Force Research Laboratory has projects under contract to develop decision tools to assist managers in identifying the most cost-effective resolution option given the stage of a particular system or subsystem life-cycle and other factors unique to the organization's decisionmaking process. This objective is only part of the 5-year, $32M ($11M in contractor cost share) initiative to improve the management of obsolescence.[20]

With limited defense funding, the cost-benefit analysis of obsolescence resolution options is critical to selecting a lasting solution at the most economical cost. It is essential

Automated cost-benefit analysis tools with what if scenarios for comparing the obsolescence resolution options would be instrumental in assisting program and item managers with timely solution decisions.

that program and item managers have the required tools to compare the monetary benefits and costs of the many options available for resolving an obsolete part. These options exist not only at the integrated circuit or part level but also at the next higher assembly levels—such as the circuit card assembly, box, or system level, making the decision even more complex. Automated cost-benefit analysis tools with *what if* scenarios for comparing the obsolescence resolution options would be instrumental in assisting program and item managers with timely solution decisions.

Obsolescence Solutions Process and Analysis

Obsolescence Resolution Process

It is important to understand that the steps described by most experts to resolve an obsolescence problem, regardless of its life-cycle stage, make the process seem fairly easy. First, an item is identified as a potential obsolete item or a manufacturer sends notification of intent to discontinue production of the item. This notification and potential problem would be disseminated to all users. In the second step, the potential obsolescence problem would be verified while determining the extent of the problem—affected end items, usage rate, and expected future requirements. Third, once the problem has been verified, the options analysis is performed to determine the best alternative for resolution of the specific obsolescence case. Finally, the most cost-effective resolution option is implemented.

Although the steps described above make the choice for resolution appear to be a simple matter of selecting the least costly option, the answer is not that simple. Cost-effectiveness implies the option achieves optimal effectiveness at the minimum cost—"the most effect for the dollar." In performing the cost-benefit analysis for the options, many factors and variables that are unknown or not easily identifiable can make the decision a very difficult one. One such example is a system's service life. Many times systems scheduled for deactivation have their system service life extended when funds are not available to procure replacement systems.[21]

Resolution Options for Obsolescence

Many experts point out that the question is not how to solve obsolescence but how to manage the problems economically in the best interest of the program. As shown below, there could be many options available for a program and item manager to resolve an obsolescence problem, and determining the most economical for a given situation can be difficult.

Many experts point out that the question is not how to solve obsolescence but how to manage the problems economically in the best interest of the program.

DoD materiel management requires item materiel managers to implement the most cost-effective solution consistent with mission requirements when an item is identified as DMSMS or obsolete and lists solution options in order of preference. DoD 4140.1-R lists the following options:

- Encourage the existing source to continue production.
- Find another source. A smaller company might undertake production that no longer is profitable for a larger company.
- Obtain an existing substitute item that will perform fully (in terms of form, fit, and function) in place of the DMSMS item.
- Obtain an existing substitute item that, while it would satisfy one or more functions, might not necessarily perform satisfactorily in all of them (limited substitute).
- Redefine military specification (MIL-SPEC) requirements through applicable engineering support activities and consider buying from a commercial source. That redefinition may include MIL-SPEC tailoring. Such a course of action might induce the emergence of additional sources.
- Use current manufacturing processes to produce a substitute item (form, fit, and function) for the unobtainable item. Through microcircuit emulation, inventory reduction may be achieved as obsolete items may be replaced with state-of-the-art devices that may be manufactured and supplied on demand. Emulation may be considered a more preferred alternative to 3 and 4 above, if the part may be used in a wide variety of functions.
- Make a *bridge* buy of a sufficient number of parts to allow enough time to develop another solution.
- Make a Life-of-Type (LOT) buy. Based on estimated life-of-system requirements, the DoD components may make a onetime procurement of enough materiel

If obsolescence is viewed as inevitable, then the function of managing obsolescence is reducing its consequences or costs.

to last until the end items being supported are no longer in use. LOT buys shall include sufficient materiel to be provided as Government Furnished Materiel (GFM) for repair and for piecework applications in the procurement of additional systems, equipment, spare assemblies, and subassemblies. Before adopting that alternative, managers should take into account the potential for criticism of excessive levels of on-hand inventory.

- If a contractor using Government Furnished Equipment (GFE) stops production, use the GFE to set up a new source.
- Reclaim DMSMS part from marginal or out-of-service equipment or, when economical, from equipment that is in a long supply or potential excess position.
- Modify or redesign the end item to drop the part in question or replace it with another.
- Replace the system in which the DMSMS item is used. [This] alternative would require extensive cost analysis.
- Require the using contractor, through contractual agreements, to maintain an inventory of DMSMS items for future DoD production demands.
- Obtain a production warranty, if possible, from the contractor to supply the item or items for a specified time (life of equipment) irrespective of demands.[22]

These methods reflect the currently documented solutions for resolution of an obsolescence problem. Each of these resolution options was also included in the Air Force case resolution guide as alternatives.

Cost-Benefit Relationships Analysis

To analyze the cost-benefit relationships of the obsolescence resolution options, it is important to understand the function of obsolescence management. If obsolescence is viewed as inevitable, then the function of managing obsolescence is reducing its consequences or costs. “Obsolescence management is primarily a tool for reducing or avoiding downstream costs, rather than generating immediate savings.”[23] Another factor that must be considered in analyzing the costs or benefits of the resolution options is risk—the risk of downstream obsolescence and the technical risk associated with redesigning the component or system.

The DoD materiel management regulation lists the resolution options in order of preference beginning with the simplest and least costly (potentially) and progressing through options with increasing costs, complexity, and difficulty. Since the options are listed by increasing cost and budgets are normally limited, a program manager's reactive approach to a notification that a manufacturer plans to discontinue production of an item generally would be to start with the least costly option and proceed down the list until the problem is resolved. However, this approach does not consider the total system implications and may cost more over the life of the weapon system. For example, finding an alternate source may solve the current obsolescence problem, but the fix may only be temporary. Likewise, a LOT buy would also resolve the current obsolescence problem but only temporarily if the demand rates increase or system service life is extended.

While the options that involve redesign and replacement may cost more in the short run, replacing obsolete technology with more current technology could reduce the total ownership cost of the weapon system in the long run.

While the options that involve redesign and replacement may cost more in the short run, replacing obsolete technology with more current technology could reduce the total ownership cost of the weapon system in the long run. Additionally, the redesign may improve system performance and reliability. Unfortunately, the technical and schedule risk associated with redesign or replacement options make them less desirable when easier solutions are available. In exploiting these redesign resolution options, it is important to take a proactive approach to predict and identify obsolete items to allow for adequate planning and scheduling the technology upgrades during normal maintenance cycles.

The Under Secretary of Defense for Logistics and Materiel Readiness, in a briefing on Transforming Logistics, stated, "It makes no sense to continue to pay increasing maintenance and support costs for out-of-date equipment or to spend money updating equipment that is no longer relevant."[24] As stated earlier, resolving obsolete parts problems are identified incorrectly primarily as reliability and maintainability issues that provide no improved capability or reduced cost; however, the objective of the obsolescence management program is to

It is critical that program and item managers have the necessary financial tools to fully analyze the resolution options and justify higher funding priorities with defendable cost avoidances and benefits.

select the most cost-effective solution. Program and item managers, in managing obsolescence, should consider each of the resolution options in light of the total ownership cost of the weapon system to avoid more costly problems downstream. This consideration does not imply that the system must be changed or upgraded; however, in certain circumstances, redesign options may include technology insertion or upgrades, which should be considered a measurable benefit if the overall operation and maintenance costs can be reduced. Therefore, it is critical that program and item managers have the necessary financial tools to fully analyze the resolution options and justify higher funding priorities with defendable cost avoidances and benefits.

Tool and Model Analysis

Model and Tool Description

"The *AFMC Case Resolution Guide* provides an approach to assist in analyzing and resolving DMSMS situations throughout weapon system acquisition and life-cycle support."[25] Additionally, the guide incorporates past obsolescence case resolution successes and encourages tracking and documenting DMSMS cases and resolutions. The contractor-developed case guide, which is referenced in Air Force guidance but not included on the DMSMS Web pages, is maintained by the DMSMS Program Office.

The case guide addresses obsolescence management from a life cycle management perspective, emphasizing a proactive approach to managing the risk associated with obsolescence issues. The guide is not only a tool for resolving obsolescence problems but also a guide for establishing an active obsolescence management program to identify and address obsolescence parts throughout a system's life cycle.

Analysis Criteria

Any criteria used to analyze a cost-benefit analysis model of the solutions discussed in the previous sections should take into consideration the prime objectives of the obsolescence management program. These objectives, as listed in materiel management guidance, are basically twofold. First, the solution identified should be the most cost-effective solution for the life of the system to minimize future impacts to the system. Second, the solution should be consistent with mission requirements as stated in terms of performance (speed, reliability, and so forth).[26] These objectives are represented in the questions identified below, which will be used as criteria to help analyze the case resolution guide identified during the literature review.

Members of the MITRE Corporation developed a life cycle cost model for one of the solutions, a LOT buy. MITRE is a not-for-profit corporation or *think tank* that works in partnership with the Government to address difficult issues through systems engineering and information technology. In developing the cost model, they developed six questions that should be considered when selecting a resolution option. These MITRE-developed questions, which will be used as criteria for evaluating the cost-benefit analysis model, included:

- How many years must the solution last?
- How well does the system, board, or box function in terms of both operations and reliability?
- How many other integrated circuits in the board, box, or system are also obsolete or will become obsolete during the remaining service life of the system?
- How many of the obsolete integrated circuits are likely to be needed?
- What options are available, and what are their relative costs?
- What is the impact of the chosen replacement strategy on operations and maintenance costs?[27]

These questions adequately emphasize the cost side of the cost-benefit analysis, and while the benefits are considered, they are addressed primarily as cost avoidance. It is important to give adequate consideration to the benefits derived from a potential resolution option. As stated earlier, the primary benefit is typically viewed as continued sustainability of the existing system. However, if the DoD is to break out of the loop of paying increasing maintenance and support costs for out-of-date equipment, another question should be included: What are the measurable benefits of the solution? Since the objective of the obsolescence management program is to select the most cost-effective solution for the life of the system

First, the solution identified should be the most cost-effective solution for the life of the system to minimize future impacts to the system. Second, the solution should be consistent with mission requirements as stated in terms of performance (speed, reliability, and so forth).

Overall, the case guide provides an adequate cost-benefit analysis of the resolution options.

consistent with mission requirements, this question will also be used as a criterion to evaluate the cost-benefit analysis model.

Model and Tool Analysis

Question 1
The case guide does consider the service life of the system. In each of the resolution options, the guide emphasizes computing the future requirements based on the projected life of the equipment and system.

Question 2
The case guide includes reliability and operational capability of the system, board, or box. The guide emphasizes that each option considered should not degrade the performance of the system.

Question 3
The case guide does include consideration for other integrated circuits in the board, box, or system for the service life of the system. The case guide not only considers other integrated circuits for the board, box, or system but also provides focal points to help identify other DoD users of the same integrated circuit.

Question 4
The case guide does include the number of integrated circuits required.

Question 5
The case guide process recommends all options be considered and calculated and provides worksheets to estimate the relative cost of each option; however, the worksheets are not electronic. The worksheets would have to be printed and completed or developed in an electronic spreadsheet program.

Question 6
The case guide does include steps to calculate the total cost of each option and refers to total ownership cost; however, the worksheets do not specifically include a resulting impact of the chosen replacement strategy on operations and maintenance costs in the worksheet calculations and comparisons.

Question 7

The case guide does not emphasize or calculate measurable benefits for each option. The case guide lists general pros and cons for each of the options; however, the worksheets do not include consideration of the benefits for each option.

Summary of Analysis

Overall, the case guide provides an adequate cost-benefit analysis of the resolution options. Specifically, the case guide emphasizes the obsolescence management program objectives—identifying a cost-effective obsolescence resolution option while maintaining performance integrity consistent with mission requirements. Additionally, the guide satisfies five of the seven criteria questions for selecting a resolution option. Although the case guide has slight provisions for the remaining two criteria questions, the guide does not calculate or emphasize the consideration of the measurable benefits or include the impact on operations and maintenance costs for each option in the decision or comparison process. Finally, the guide is very detailed in providing guidance to the program and item manager on specific cost considerations for each option and ideas of where and how to obtain the data when completing the analysis.

While the *Air Force Materiel Command (AFMC) Case Resolution Guide* is an adequate tool, the tool's process is manual and does not allow *what if* scenarios to perform sensitivity analysis and determine how sensitive the analysis results are to anticipated changes in the estimated costs or benefits. An automated cost-benefit analysis tool would allow the program and item manager to save time in developing the comparison calculations for the part, board, or assembly level and formatting analysis results and spend more time on the data and issues that matter.

While the AFMC Case Resolution Guide is an adequate tool, the tool's process is manual and does not allow what if scenarios to perform sensitivity analysis and determine how sensitive the analysis results are to anticipated changes in the estimated costs or benefits.

Summary

An increase in electronic combat technologies, the extension of weapon system service life, rapid technology advancements, and the shrinking military market have increased the historical problems of obsolete parts. With limited defense funding, the cost-benefit analysis of

Adequate automated tools to perform cost-benefit analysis do not currently exist.

obsolescence resolution options is critical to selecting a lasting solution at the most economical cost.

Many experts point out that the question is not how to solve obsolescence but how to manage the problems economically in the best interest of the program. Several automated tools designed to predict future obsolete parts early in the system's life cycle are available. However, these tools do not include cost-benefit analysis of the obsolescence resolution options. If obsolescence is viewed as inevitable, then the function of managing obsolescence is reducing its consequences or costs while minimizing the risks of the resolution option selected. Only one existing cost-benefit analysis tool, the *AFMC Case Resolution Guide*, is identified by this project to assist program and item managers in making the difficult and complex decision of identifying the most cost-effective solution for an obsolete part.

While the *AFMC Case Resolution Guide* is an adequate tool, the tool's process is manual and does not allow *what if* scenarios to determine how sensitive the analysis results are to anticipated changes in the estimated costs or benefits. An automated tool would allow the program and item managers to save time on developing the comparison calculations for the part, board, and assembly level and formatting analysis results and to spend more time on the data and issues that matter. Additionally, the guide does not calculate or emphasize the consideration of the measurable benefits or include the impact on operations and maintenance costs for each option in the decision or comparison process.

Conclusion

Program and item managers need financial tools to compare the monetary benefits and costs of the many options available for resolving an obsolete part. Adequate automated tools to perform cost-benefit analysis do not currently exist. The Air Force does have an ongoing effort to develop an automated tool. In the interim, the case guide is an adequate model for program and item managers to use to perform cost-benefit analysis of the obsolescence resolution options.

Recommendations

The Air Force should include in the *AFMC Case Resolution Guide* emphasis on and calculations for the measurable benefits associated with a resolution option and consideration for the impact on total operations and maintenance costs for each option on the calculation worksheets.

The Air Force should continue development of automated cost-benefit analysis tools to include impact to overall operational and maintenance cost and consideration for measurable benefits.

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Shaping Logistics—Wargames

As you can well imagine, this is not an easy task or one that creates universal consensus in the Air Force logistics community. However, the utility of exploring new logistical concepts in wargames versus real life quickly becomes obvious when you look at the funds, personnel, and equipment impacts associated with live exercises. In exercises such as Foal Eagle or Cope Thunder or older exercises like Reforger or Bright Star, you discover the manpower, financial, and equipment costs are extremely high. In these exercises, we deploy up to 10,000 people and their equipment for a month or more to distant parts of the earth. With preparation, the actual exercise, and reconstitution, these personnel and their units are often unavailable to respond to other taskings for 3 to 4 months. In terms of financial cost, live exercise costs often run into millions of dollars and contribute to increased wear and tear on critical weapon systems and our airlift fleet. These were valuable exercises, and we learned a great deal from them, but there was certainly a sizable bill to pay for each.

Wargames cannot completely reflect the real world; however, you can draw close parallels with sufficient fidelity to allow functional experts to determine if concepts are feasible and workable and if other advanced testing methods, such as live exercises, are appropriate. Or you may determine a concept is simply unworkable and unrealistic and should be sent back for rework or totally scrapped. Further, in a wargame, you don’t require massive numbers of troops, you don’t wear out weapon systems, and you require only a fraction of the dollar outlay that live testing requires.

In games such as Focused Logistics, Global Engagement, and Futures, a broad range of logistical concepts are explored that will allow us to better support the warfighter and the expeditionary air force. Concepts such as forward operating locations, forward support locations, various types of prepositioning (including prepositioning ships), redesigned maintenance and support kits, ways to increase the velocity of the resupply pipeline, and intermediate depot-repair sites are typical of what’s being examined and evaluated.

Wargames have the added advantage and flexibility of being able to explore today’s concepts or those 25 years in the future. With today’s concepts, we can validate the outcome with an increased level of fidelity because the reliability of the data is high. Even with concepts set many years in the future, we can determine if the concept is feasible with envisioned technology.

Wargaming is a valuable force multiplier for the Air Force. We can explore concepts and determine outcomes for a fraction of the cost of live exercises and not lose or damage a single aircraft or put the first airman in harm’s way. It’s a valuable tool in the logisticians’ toolbox, and its use will grow in importance.

Captain Timothy W. Gillaspie, USAF
Colonel Kenneth P. Knapp, USAF

Cannibalization is the removal of a serviceable component from one aircraft to repair another aircraft because of a lack of components in the supply system.

Introduction

The Hangar Queen (HQ) program was established to prevent aircraft from becoming a permanent parts-donor aircraft. In the past, aircraft had been left down as the designated cannibalization (cann) aircraft so long that a major effort was required to return them to flight because of the number of parts removed and documentation problems. Any discussions concerning the need for an HQ program are usually met with examples of aircraft hulks being hidden in a hangar, never to fly again, and statements concerning the negative effects of keeping an aircraft on the ground too long. To prevent this from happening, several major commands (MAJCOM) established HQ programs requiring command-level oversight for aircraft that were down an established time. The problem with these programs was that no indepth study was performed to determine the appropriate HQ threshold. As early as the mid-1980s, the prescribed down times associated with the different command HQ programs were not standardized even though they operated the same types of aircraft. The focus of this article is to look at the history of the different command HQ thresholds, review previous HQ and cann studies,

Hangar Queen

investigating the effects of the program

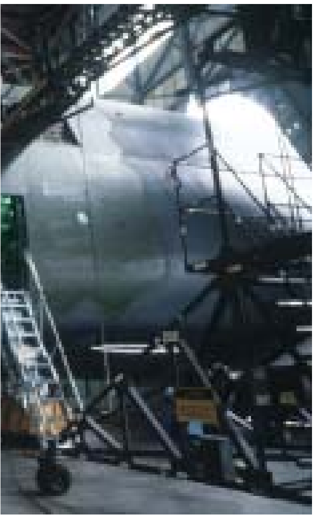
Major Kelly J. Larson, USAF

and assess the current field maintenance leadership opinions of the HQ thresholds. This study included the impact of the standards on aircraft canns and aircraft availability. The root of this issue is lack of parts, which leads to the need to cannibalize parts and consolidate the missing components to the least number of aircraft to increase aircraft availability.

Understanding Cannibalization

Our fundamental policy is to cannibalize only when it is absolutely mission-critical.

—Lieutenant General Michael E. Zettler, Air Force Deputy Chief of Staff, Installations and Logistics



Cannibalization is the removal of a serviceable component from one aircraft to repair another aircraft because of a lack of components in the supply system. Because canns double the maintenance workload, specific guidance and procedures are in place at the command and unit level to help control or minimize them. Because there is no realistic way to prevent the need for canns, it is important to ensure that canns resulting from command guidance, such as the HQ program, are minimized and performed based on a validated requirement.

Cost of Cannibalization

Cannibalization is a quality-of-life issue.

—Lieutenant General Michael E. Zettler, Air Force Deputy Chief of Staff, Installations and Logistics

Cannibalization is a major issue as evidenced by the numerous studies, audits, and congressional testimonies on the subject.

Cannibalization is a major issue as evidenced by the numerous studies, audits, and congressional testimonies on the subject. While canns are a necessity and have become a way of life in today's Air Force, they bring with them numerous effects, ranging from increased workload to a negative impact on the morale of aircraft maintenance technicians. Cann rates are measured as a metric of canns per 100 sorties. "In FY00, the total USAF maintenance man-hours expended on cann were over 561,000 maintenance hours—approximately 2 percent of all maintenance man-hours dedicated to all aircraft maintenance that year."[1] As outlined in Figure 1, canns require at least twice the maintenance time of normal repairs.

While there is no study to examine the impact of canns on the components themselves, it is obvious that this does cause additional wear and tear on parts to include the ones removed to gain access to the needed component. Canns have always been a major morale problem for maintenance personnel as evidenced in an April 1984 Air Force Human Resource Laboratory Study.[2] In recent years, the need to cannibalize has been defined as a quality-of life-issue for aircraft maintenance personnel. The additional workload has a negative impact on morale and is even being attributed to low retention rates for maintenance technicians. It is with this thought in mind that this article emphasizes the need to ensure canns performed to support the HQ program are based on a validated, *rea*l need to get the aircraft back into the air. There have been several studies on canns and the HQ program, and while their recommendations have not been well received, they have contributed to the recent shift in extending HQ thresholds and loosening requirements for reporting HQ aircraft.

Aircraft Availability

Another key element is aircraft availability. It is a daily struggle for aircraft maintainers to match the number of aircraft available with flying, maintenance training, and scheduled maintenance requirements. To maximize aircraft availability, units designate aircraft as *cann jets* to consolidate unavailable parts to one aircraft. These aircraft are the main focus of this article. The impact on availability is seen during cann jet *swap out* when two aircraft are unavailable for scheduling purposes. Though the HQ program is not the only reason for cann jet *swap out*, it is a driving factor.

Aircraft Availability Impact

Because nearly every fighter squadron will have its own cann jet, the HQ threshold issue can also impact aircraft availability. This issue comes into play when two aircraft are down for cann. During cann jet swap out, one aircraft is in rebuild, and one is being taken down as the new cann jet. If we assume a standard swap-out period of 3 days, we can see the result of a 30- versus 50-day HQ threshold. Assuming cann jet turnover is driven solely by the HQ threshold, there would be five less swap outs under the 50-day threshold. In a wing with three fighter squadrons, this would equate to having an additional aircraft for scheduling 45 days per year. This example would also provide the potential to avoid 1,080 hours of nonmission-capable time. These savings show the potential for extending the time an aircraft is a cann jet. The goal should

Until recently, there was no Air Force-level guidance on the HQ program.

be to give the units the ability and direction to capitalize on these potential savings by leaving the aircraft down when another maintenance management consideration, such as phase flow, or another aircraft breaking for an *uncannable* part does not drive the swap out.

Current HQ Program Guidance and Its Effects

Until recently, there was no Air Force-level guidance on the HQ program. In looking at the command guidance, around 1995, there was a push to publish Multicommand Instruction (MCI) 21-101, *Maintenance Management of Aircraft*, to replace the individual commands' 21-101 instructions. Over years of independently managing their own supplements to Air Force Instruction (AFI) 21-101, the MAJCOMs had developed command-unique guidance for the exact same tasks and requirements. The goal of the MCI was to standardize guidance and procedures to the maximum extent possible for the combat air forces.

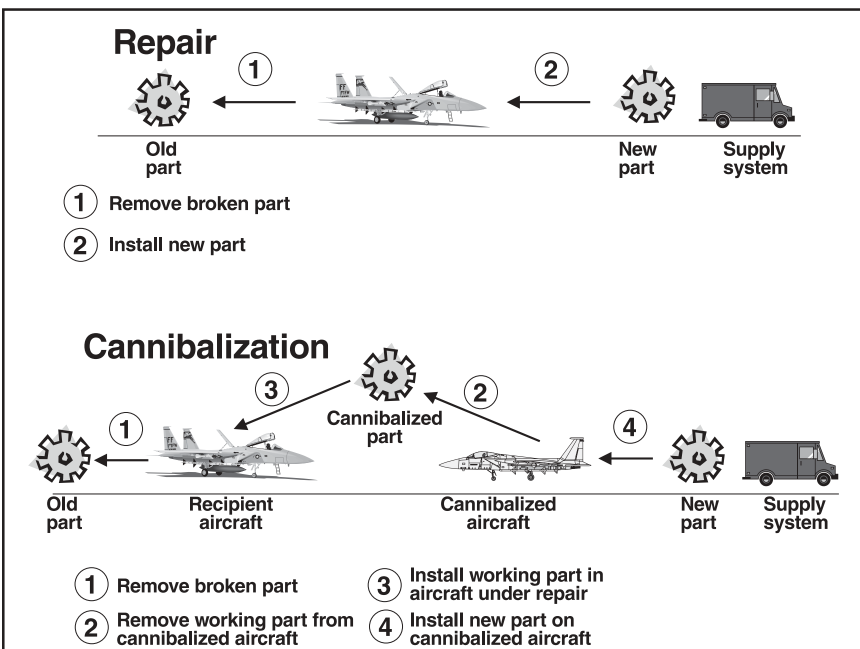


Figure 1. Repairs Require Two Actions; Canns Require Four

Exceptions to standardization were made on maintenance issues where the commands could not come to an agreement. The intent was to minimize these exceptions by ensuring they were driven by a unique operating environment in a command, not based on tradition or individual preferences. HQ thresholds were one area where the commands could not come to a consensus.

Over years of independently managing their own supplements to AFI 21-101, the MAJCOMs had developed command-unique guidance for the exact same tasks and requirements.

Air Combat Command

As outlined in Air Combat Command Instruction (ACCI) 21-101, *Maintenance Management of Aircraft*, the purpose of the HQ program is to encourage aggressive management of the maintenance actions required to prevent aircraft from becoming HQs. When an aircraft becomes an HQ, managers at all levels must intensify their effort to alleviate the HQ condition as soon as possible and comply with the responsibilities for each category of HQ. An HQ is defined as an aircraft that has not flown for more than 30 consecutive days. ACC has somewhat relaxed the reporting procedures for HQ aircraft by establishing three categories for HQ aircraft. Category 1 includes aircraft that have not flown for more than 30 but less than 60 days. These aircraft require a dedicated recovery team, indepth quality assurance, strict control of canns at the deputy operations group commander for maintenance (DOGM) level, and reporting the aircraft as an HQ in the monthly MAJCOM metric-reporting program. Category 2 HQs are aircraft that have not flown for more than 60 days but less than 90 days. In addition to the level 1 requirements, units should cease all canns, make the aircraft a priority for rebuild, and brief the aircraft's status to the operations group commander. Category 3 HQ aircraft have not flown for more than 90 days. Once an aircraft reaches this level, units must comply with all level 1 and 2 requirements plus brief the wing commander on the aircraft's status, cannibalize all parts needed to bring the aircraft to airworthy status, advise the MAJCOM logistics commanders of any needed components that are unfeasible to cannibalize, and perform at least an operations check flight to return the aircraft to service. Aircraft that become level 2 or 3 HQs must be reported to the MAJCOM logistics commander via message to include reason for HQ, *While the commands' goals are to ensure increased supervisory involvement in aircraft that are down for extended periods, the key difference between the 30- and 50-day thresholds is the reporting and tracking of HQs to and by the higher headquarters.*

estimated fly date, and supply information for the parts on order. While these criteria and requirements have been relaxed compared to the 1986 21-day HQ threshold for fighters, it can still drive units to take actions, canns, to return aircraft to flight before the 30-day window is passed. The question becomes whether the benefits from keeping a jet in *cann status* longer outweighs the potential for the additional work to return the aircraft to flight after a longer period of downtime. [3]

PACAF

Pacific Air Forces' (PACAF) current HQ guidance mirrors the ACC guidance with the exception that a category 1 HQ is an aircraft that has not flown for 51 to 60 days. The PACAF HQ threshold was extended from 30 to 50 days in 1994. The change was initiated by a 1993 Air Force Logistics Management Agency (AFLMA) study on HQ threshold methodology. The study was followed by a 6-month test at two PACAF locations to validate the change in policy. The rationale for the change was reduced cann rate and man-hours, less wear, tear, avoidance of occasional breakage of components, and no negative impact on return to flight or supply support.[4]

USAFE

The United States Air Forces in Europe (USAFE) current HQ guidance matches PACAF's. Originally, USAFE maintained the same threshold as ACC, but in September 2000, USAFE adopted the 50-day standard. This change was based on a desire to increase aircraft availability by decreasing the number of times two aircraft would be down for cann jet swap out. USAFE also wanted to provide the field units more flexibility in making the right management decisions on when to return cann jets to flight. Because there had been no indepth studies performed to determine the right threshold, USAFE chose to extend its standard based on PACAF's experience with the 50-day standard.[5]

Air Staff Guidance

The most recent development on this issue is the addition of an HQ section in AFI 21-101, dated 13 February 2002.

This addition has two key sentences as part of its general guidance: "Cannibalization will not be used to return the aircraft to a flying status for the sole purpose of preventing HQ reporting. Reporting procedures are intended to provide higher level assistance to field units and will not be construed as a report card."[6] This guidance does not say canns should not be used to return the aircraft to flight; rather, those canns should not be driven by the HQ program.

While neither of the current thresholds is the right number, we can examine the effects of the two programs to determine which one has the most benefits and then standardize it across the combat air forces.

Management Effects of the Different Thresholds

While the commands' goals are to ensure increased supervisory involvement in aircraft that are down for extended periods, the key difference between the 30- and 50-day thresholds is the reporting and tracking of HQs to and by the higher headquarters. The fact that category 1 HQs are being reported as part of the wing's monthly metrics to HQ ACC after 30 days will push some units to take the actions necessary, canns, to avoid what is perceived as a negative statistic. The new Air Staff guidance needs to be emphasized to ensure units understand its intent. MAJCOM guidance needs to reenforce the new AFI 21-101 guidance on not performing canns to solely prevent HQs. All aircraft maintainers will agree there is a limit to the number of days an aircraft can remain on the ground without causing problems in returning it to flight. The problem is that the HQ thresholds have been arbitrarily determined based on anecdotal evidence or beliefs. While neither of the current thresholds is the right number, we can examine the effects of the two programs to determine which one has the most benefits and then standardize it across the combat air forces. The HQ program needs to continue to increase management oversight on aircraft down for extended periods; however, it should not drive maintenance actions based solely on a calendar. Maintenance actions should be driven by a validated requirement to return the aircraft to service.

Review of Previous Studies

Research revealed several studies on the issue of HQ programs and canns. The data, recommendations, and reactions and comments of various commands and

Research revealed several studies on the issue of HQ programs and canns.

agencies to the findings and recommendations of the various studies follow. These studies cover a period from 1986 to 1994 and include Air Force audits, AFLMA studies, and major command tests.

Management and Control of Aircraft Cannibalizations within Tactical Forces, Air Force Audit Agency (AFAA) Project 5096511, 18 June 1986

This report focused on a 12-month period ending 30 June 1985. During the period covered by this report, there were 155,700 canns, consuming 968,000 man-hours and representing the equivalent of 465 maintenance positions.[7] One of the goals was to evaluate the adequacy of controls over cann. The audit took a hard line concerning canns as outlined in Technical Order (TO) 00-20-2, which restricted canns to priority mission requirements and further limited them to unusual circumstances. This audit had a specific section focused on management of the command HQ programs. Tactical Air Command (TAC) guidance specified a 21-day HQ threshold for fighter aircraft and 30 days for nonfighter aircraft. One interesting point is that, even in 1986, PACAF and USAFE had a different HQ standard of 30 days for fighter aircraft. The report gives credit to the HQ program for reducing the number of aircraft grounded for an extended period. In TAC, the number of reported HQs declined from approximately 160 in 1980 to fewer than 10 in 1985. However, it states that the emphasis, expressed or implied, to avoid reporting HQs resulted in unnecessary canns.[8]

Audit Findings. Not surprising, the audit found that the less time allowed before HQ reporting was required, the higher the number of canns because the supply system had not been given the ability to supply the part. Of the 162 canns for HQ avoidance reviewed in TAC, 84 were provided by the supply system within the 21-day criteria. If a 30-day standard had been used, 101 of the parts would have been issued by supply, a 17-percent decrease in the need for canns. For 32 canns performed overseas for HQ avoidance, 16 parts were received within the 30-day standard. Under a 40-day standard, supply would have provided 26 of these parts, a 63-percent cann reduction.[9] System deterioration was provided as a rationale to support command HQ thresholds, but there were no analytical data to support the specified standards or explain the differences in the command standards for similar aircraft.

Key Recommendation and Management Comments. The key recommendation for the HQ program was for the Air Staff to perform analysis to determine the amount of time an aircraft can be down without causing damage and use this as the basis for the command HQ standards. In response to this, the Air Staff concurred with the intent but not with the recommendation. They pointed out that there is no one period of time to keep an aircraft down without damage. Because of the multiple variables, the Air Staff focused on developing aircraft inspection criteria for aircraft not flown in 30 or 90 days. The Air Staff said the HQ threshold issue would be reviewed as part of the Rivet Repair initiative.[10] This group of representatives from the MAJCOMs would "provide recommendations on HQ program alternatives, including development of an Air Force HQ program and the standardization of MAJCOM programs. Estimated completion date is 31 July 1986."[11] It seems they were unable to take the action outlined in the Air Staff's response to this recommendation.

Management of Aircraft Cannibalization AFAA Project 91062014, 1 October 1992

This audit was very similar to the one performed in 1986. It focused on two key aspects of cannibalization. First, whether the canns were appropriate. Second, how well cann data were captured in the maintenance data-collection system. This study reviewed 8,893 cann actions between 1 April and 30 June 1991 at 18 bases. Though the first aspect is the main concern of this article, the second indicates that cann data may be understated by approximately 10 percent in the maintenance data-collection system, and visibility of serially controlled assets may be impacted.[12]

Audit Findings. From the population of 8,893 canns studied, 1,998 were isolated as actions taken to prevent aircraft from becoming HQs. Of these, 882 actions had known dates for the receipt of the needed component. By comparing the receipt date of the part with the date of the associated cann, the auditors were able to determine the impact of extending the HQ threshold by 7 days. The results showed that, at 16 of the 18 locations, 596 canns

The results showed that, at 16 of the 18 locations, 596 canns could have been avoided by allowing the aircraft to remain down an additional 7 days

could have been avoided by allowing the aircraft to remain down an additional 7 days (Table 1).[13] Similar to the 1986 audit, this report cited that the commands did not have completed studies or other documentation that showed HQ thresholds were based on expected supply response times and the periods of inoperability that can occur without damage to aircraft systems. This issue was further highlighted by pointing out the different HQ standards between commands operating the same aircraft. The auditors felt that the Air Force could save maintenance costs and maintain the same level of mission capability by extending the HQ threshold.

Key Recommendation and Management Comments. As a result of this audit:

> …the AF/LG should require the operating commands to reassess and, as appropriate, revise the HQ threshold considering (a) expected supply response times and (b) the periods of inoperability that can occur without damage to the aircraft systems.[14]

In response, the HQ USAF/LG stated:

> Concur with intent. An increasingly business-oriented Air Force suggests the need for a consistent yet flexible HQ threshold methodology based on objective and subjective factors. MAJCOM and wing organizational changes, DMRDs [Defense Management Report Decision], and stock funding issues—elements not part of this audit—should also

Days Between CANN and Parts Receipt	Number of CANN Actions	Number of Maintenance Hours
0	147	640.50
1	124	633.85
2	72	419.10
3	72	284.90
4	54	342.90
5	53	202.60
6	41	306.30
7	33	187.20
Total	596	3,017.35
Source: Air Force Audit Agency, Management of Aircraft CANN Report of Audit, Project #91062014, 1 Oct 92		

Table 1. Potential Reductions of Cann Actions

> be considered in developing such a methodology. AF/LG has tasked the AFLMA to (a) study the Air Force Audit Agency recommendations and the other elements just cited and (b) develop an HQ threshold methodology based on that study's findings. This methodology will be adaptable to MAJCOMs with differing missions, locations, and possessed aircraft—and implementable at MAJCOM or wing levels. Estimated completion date is 1 February 1993.[15]

Instead the typical knee jerk maintenance response based on opinions and anecdotal data was provided.

ACC/USAFE/PACAF Responses to Audit #91062014

In July 1992, Air Force Logistics and Maintenance sent a message to all MAJCOM logistics and maintenance directorates requesting their views and alternative recommendations on the subject audit. The wording of the message was somewhat inflammatory and incorrectly stated that the audit requested individual HQ programs for each mission-design series (MDS). After reviewing the MAJCOM responses, this became an emotional issue where the MAJCOMs did not honestly evaluate the findings. Instead, the typical *knee-jerk* maintenance response, based on opinions and anecdotal data, was provided. The MAJCOMs sought to defend what they perceived as an attack on their HQ programs rather than looking to review and make adjustments to the thresholds. Given these reactions, it is easy to see the resistance to extend the threshold or even contemplate the need for the program.

In their response, ACC was quick to point out that it "does not have an arbitrarily established HQ policy."[16] Next, the issue of skeletal remains of what was once a fighter aircraft, documentation problems, and potential aircraft accidents are brought up. Finally, the basis for ACC's HQ threshold is stated "based on the flight-line experience of command officers and senior enlisted maintenance personnel who were concerned for the safety, reliability, and airworthiness of valuable resources."[17]

The USAFE response defended its HQ program. Its main point was, "Given the current spare parts situation …regardless of what the HQ threshold is, canns are going to be required to avoid HQs."[18] The basis for the USAFE threshold was stated as:

> Experience shows that cann aircraft down time should not exceed 30 days to ensure that aircraft can be safely returned

PACAF also disagreed with establishing longer MDS-standardized HQ thresholds.

> to operational service. Experience also shows us that aircraft down for extended periods of time had other aircraft systems fail that were not related to the cann actions. An example is aircraft seals drying out due to lack of use.[19]

PACAF also disagreed with establishing longer MDS-standardized HQ thresholds in its reply. The message starts out by citing the same type of emotional issues:

> …every base had at least one and sometimes several aircraft which had been so long and so extensively cannibalized that recovery was virtually impossible. Bitter experience taught us that the longer an aircraft was unutilized, the more difficult it was to recover as a sortie-producing asset, not only because seals had deteriorated and other mechanical degradation had taken place ….[20]

PACAF also disagreed with the audit's finding that avoidable canns occurred because operating commands established arbitrary HQ policies and stated that the HQ threshold does not force canns per se. It goes on to say that since the HQ threshold does not directly drive canns, extending the time would not automatically decrease them and firmly opposes extending the threshold. Finally, PACAF did agree on establishing a standardized HQ threshold for the combat air forces but would oppose anything over 30 days.[21]

Developing an Objective HQ Threshold Methodology, AFLMA Project LM922168

As tasked by Air Force Logistics, the Agency took on the controversial task of developing an objective HQ threshold. The project called for comparing data on the same MDS from units operating under an HQ program and units without an HQ program. Interviews were conducted at the field and depot levels to address traditional maintenance issues concerning the HQ program. The report did not find evidence that an HQ threshold was either beneficial or harmful to an F-16. It was also unable to find any quantitative evidence of excessive maintenance resulting from the HQ threshold policy, but interviews indicated that almost everyone believed this to be true.[22] In response to the HQ program's preventing units from turning their aircraft into shells, the study showed that this does not happen at units without an HQ program. Based on these facts, the report recommended the commands consider eliminating the HQ program. Of course, this recommendation brought on another emotional-based response from the MAJCOMs. The study failed to produce hard data to determine the right number of days for an aircraft to be on the ground. The study needed to focus on the costs and benefits of swapping out cann jets less frequently. Only two responses were located.

The first response to the report was from the Air Training Command (ATC) Logistics Director. He stated that the researchers missed the point of the HQ program and strongly disagreed with the recommendations. The real intent of the HQ program was to force units to work the *hard broke* aircraft and get them flying instead of using only the *good flyers*. Comments from depot personnel concerning the benefits of leaving a cann jet down longer were a smokescreen because it is easier for them to manage parts based on a supply rate instead of preventing HQ aircraft.[23]

The ACC Logistics Director concurred with the ATC Logistics Director and stated that the report measured the cost of the HQ program but was unable to measure the benefit. He used a metaphor to help point out the unseen benefits: "Just because children no longer contract what was a once-fatal diseases is no reason to eliminate an immunization program."[24] The fact that there are no *dust covered* aircraft in a hangar that have not flown for a year causes people to see the HQ program as a nuisance.[25]

The report did not find evidence that an HQ threshold was either beneficial or harmful to an F-16. It was also unable to find any quantitative evidence of excessive maintenance resulting from the HQ threshold policy, but interviews indicated that almost everyone believed this to be true.

PACAF Test of a 50-Day HQ Threshold

Following the AFLMA study, Air Force Logistics and Maintenance sent a memorandum to the commands to summarize the recent efforts concerning the HQ program:

> Although the issues raised in this AFAA audit and AFLMA report generate diverse views, we believe such dialogue is constructive and results from the fact that this audit concerns issues important to our convictions on how best to maintain readiness and defend budgets.[26]

It was left up to the MAJCOMs to determine whether or not to establish an HQ threshold. If established, HQ thresholds "should be based on a defendable and published methodology that is based on objective and subjective

To perform this 6-month test, PACAF selected both F-15 (Kadena) and F-16 (Misawa) bases for the 50-day threshold.

factors."[27] This guidance generated a test of a 50-day HQ threshold in PACAF. While it seems there was no real scientific method to select 50 days as the potential standard, it was an attempt to validate the effects of extending the HQ threshold.

To perform this 6-month test, PACAF selected both F-15 (Kadena) and F-16 (Misawa) bases for the 50-day threshold. Two MDS bases were selected within PACAF to maintain the 30-day standard for comparison of F-15s (Elmendorf) and F-16s (Kunsan). This would help ensure a fair comparison of the 30- and 50-day standards under similar conditions. The test focused on cann rates, neutralized parts availability by dividing cann rates by the total nonmission-capable supply (TNMCS) rates, and compared actual number of man-hours for canns. The results of the test showed no negative impact on supply support, maintenance documentation, or flight discrepancies as a result of the extended downtime. Though unable to be confirmed by this test, it was felt that fewer canns would also reduce wear and tear and occasional breakage of components. As shown in Tables 2, 3, and 4, the test units were able to reduce cann rates and the numbers of man-hours for canns significantly more than both their previous year's and the control base's statistics. Based on the test data, PACAF extended its HQ threshold to 50 days for the entire command in September 1994. In September 2000, the results of this test were used to increase the USAFE threshold from 30 to 50 days.[28]

Results of Field-Level Logistics Commanders and DOGM HQ Threshold Questionnaire

To assess the field-level maintenance leadership's perspective of the HQ program thresholds, a four-question survey was sent to the logistics group commanders and deputy operations group commanders for maintenance at combat air force bases. Out of the 48 questionnaires sent, 20 replies were received. Two questions were most successful in eliciting responses concerning their opinion of the HQ program and thresholds. The responses could be divided easily between supporters of the shorter ACC HQ threshold and those that favored a longer standard. Several of the respondents were able to supply a personal perspective of both programs because of assignments and experience under the guidelines. Another theme consistent in all the questionnaires was the need for more parts in supply to prevent cannibalization from being a normal cost

Location	Prior Year's Rates	Test Period Rates	Percent Change
Kadena (F-15 Test Base)	11.1	9.9	-11%
Elmendorf (F-15 Control Base)	16.5	15.6	-5.5%
Misawa (F-16 Test Base)	8.6	6.7	-22%
Kunsan (F-16 Control Base)	10.6	9.1	14%

Table 2. Cannibalization Rates
Source: 1994 PACAF 50-Day HQ Threshold Test

Location	Prior Year	Test Period	Percent Change
Kadena (F-15 Test Base)	1.87	1.04	-44%
Elmendorf (F-15 Control Base)	1.62	1.34	-17%
Misawa (F-16 Test Base)	1.40	0.87	-38%
Kunsan (F-16 Control Base)	1.83	1.47	-19%

Table 3 Cann Rate and TNMCS Rate
Source: 1994 PACAF 50-Day HQ Threshold Test

Location	Prior 6-Months	6-Month Test Period	Percent Change
Kadena - # CANNs	705	642	-%
- # Man-hours	5,844	4,188	-%
Misawa - # CANNs	460	360	-%
- # Man-hours	4,172	3,646	-%

Table 4. Cann and Man-hour Reductions
Source: 1994 PACAF 50-Day HQ Threshold Test

To assess the field-level maintenance leadership's perspective of the HQ program thresholds, a four-question survey was sent to the logistics group commanders and deputy operations group commanders for maintenance at combat air force bases.

of meeting the mission. Every survey felt that a command HQ program was needed; however, the opinions of the appropriate threshold varied between the ACC 30-day standard and a longer standard of around 50 days.

Supporters of the ACC 30-day Threshold

> *I think the ACC approach is best. Thirty days is local management attention. Sixty days draws HQ attention. Aircraft go over 30 days for a lot of good reasons, rarely mismanagement, but it happens and is best controlled (and decided) at the wing level. After that, aircraft are held down over 60 days for higher level support issues, such as CLSS time/priorities, parts availability, et al, areas that higher headquarters could help with.*
>
> **—LG/DOGM Survey Respondent**

Of the seven responses that supported the ACC 30-day standard, it was clear that two people felt the 30-day threshold was only a local management issue. While they would try to return the aircraft to flight within 30 days, the graduated ACC program still provided the flexibility to keep the aircraft down longer if the situation required. The more traditional hardcore maintenance approach was taken by four of the respondents. These maintainers were against any extension of the threshold, and one even preferred to swap out cann jets every 2 weeks. The rationale for less time on the ground was based on a belief the benefits of increased downtime did not outweigh the costs. Specifically, the increased difficulty in rebuilding a cann jet and the problems of getting the aircraft back to flying were cited as the reason to minimize downtime. The last of the seven responses did not supply enough information to determine the basis for preference of the ACC threshold.

Supporters of a Longer Threshold

> *I would agree with extending the length to 50 days. Being in ACC, my wing started rebuilding cann jets after 21 days of cann status to avoid our cann bird from going into HQ status. We have since decided to extend the days an aircraft is in cann status to 42 days. At the 30-day point, we comply with ACC requirements for category 1 and then start rebuilding the cann jet at the 42-day point. This decision helped to cut down the*

> *number of canns we do, saving man-hours and wear on equipment. I personally do not see the need for the requirements ACC puts on us at the 30-day point.*
>
> **—LG/DOGM Survey Respondent**

Of the 13 surveys that supported a longer threshold for HQ status, at least 5 opinions were based on experience with both the 30- and 50-day standard. These individuals indicated they see the benefits of keeping an aircraft as a cann jet longer without negative impacts on returning the aircraft to flight. Two of these maintainers have seen these benefits at their current ACC base after deciding locally to accept category 1 HQs. One person pointed out the additional savings created by using components that are awaiting installation in the cann jet, instead of having to expend the man-hours for the removal. This almost provides a forward supply point for high-usage items with intermittent availability in the supply system. Most of the individuals favoring the longer threshold believed the extended downtime gave the supply system more time to provide the part as high-priority, mission-capability requisition. This decreased the occurrence of multiple canns of the same part from cann jet to cann jet

Of the 13 surveys that supported a longer threshold for HQ status, at least 5 opinions were based on experience with both the 30- and 50-day standard.

Conclusions

> *We cannibalize only as a last resort.*
>
> **—General Michael Ryan, House Armed Services Committee Testimony, 27 September 2000**

While it is hard to dispute that command HQ programs were originally needed to offset a lack of maintenance discipline in the field, the program's purpose in today's maintenance environment still needs a hard look. If it is agreed that it is still a good idea to have command-directed, structured management oversight of aircraft that have been down for extended periods of time, program guidelines still must be examined to make sure they were based on validated requirements. Once it is agreed that the program is needed and criteria are established for fighter aircraft based on data, these requirements should be standardized throughout the combat air forces. The controversy over the basis for establishing HQ thresholds is as valid today as it was when the programs were originally established. Except

Based on the research, the first belief is, whatever the threshold, it should be standardized across the combat air forces.

for the 6-month PACAF test, no head-to-head studies have been done to measure the effects of the 30- and 50-day HQ thresholds. While neither of these standards may be the right number, there should be little doubt that the 50-day threshold is more beneficial. As with any issue, this can be disputed, but all the studies indicate it is true. The longer threshold provides the field with more flexibility and removes the perceived negative aspect of leaving aircraft in cann status longer. Though some units under the ACC 30-day threshold have made a conscious decision to accept category 1 HQs, others will still expend maintenance resources to prevent even a category 1 HQ. Canns to rebuild a cann jet will never be completely prevented by a longer threshold; however, a shorter threshold can and does drive more canns. Cann jet swap out is based on numerous factors: phase-time issues, hard breaks on other aircraft, or unavailability of parts that cannot be cannibalized. Swap outs performed solely to beat the 30-day HQ clock are not based on a validated requirement and should not be driven directly or indirectly from the MAJCOM. The intent is not merely to avoid canns, just to ensure cann man-hours are expended for the right reasons. Canns should always be performed to ensure the maximum number of aircraft are available, not only for the day’s schedule but also to be ready to go to war.

Based on the research, the first belief is, whatever the threshold, it should be standardized across the combat air forces. Initially, it was thought to recommend standardizing the 50-day threshold based on PACAF’s experience. But based on the recent inclusion of an HQ section in AFI 21-101, discouraging canns solely to avoid HQs, there is a different way to use the ACC requirement to report a 30-day category 1 HQ in the monthly metrics to the MAJCOM. While research did not determine the right downtime for fighter aircraft, it did demonstrate the benefits of keeping an aircraft in cann status beyond the 30-day threshold when other aircraft management considerations allow. If the intent of TO 00-20-2 and AFI 21-101 is to discourage unnecessary canns and all the data indicate extending cann jet downtime beyond 30 days is beneficial, units that never let their cann jets become category 1 HQs are not managing their fleet as effectively as units that allow category 1 HQ to occur. This new interpretation turns the category 1 HQ metric on its head. It changes the negative perception of having cann jet become a category 1 HQ into a positive indication of effective fleet management.

The ACC guidelines should be standardized, but only if clear guidance is provided to field units to ensure that canns for the sole purpose of avoiding a category 1 HQ will not be performed as outlined in AFI 21-101. Just because the command does not feel the 30-day threshold is driving cann jet swap outs does not mean that the units are not cannibalizing to prevent reporting what is currently perceived as a negative metric. As part of this, units should be informed that extending cann jet downtime beyond the 30-day threshold, when other maintenance considerations allow, is a positive metric showing effective fleet management. The new goal should be to have as many cann jets as possible become category 1 HQs without letting them progress to category 2 unless circumstances dictate. The category 1 HQ metric could then provide the MAJCOM and Air Staff with an indication whether units are complying with the new AFI 21-101 HQ cann guidance and the intent of the Air Force senior leadership to reduce canns. With this in mind, it is not known how many cann jets should become category 1 HQs in a squadron for a given year, but a squadron that does not have any is swapping out cann jets based on the traditional, invalidated belief about aircraft downtime. To do this, it is performing canns for the sake of returning the aircraft to flight before the 30-day threshold is reached, which goes against TO 00-20-2, AFI 21-101, and the senior Air Force leadership's intent to reduce canns.

The ACC guidelines should be standardized, but only if clear guidance is provided to field units to ensure that canns for the sole purpose of avoiding a category 1 HQ will not be performed as outlined in AFI 21-101.

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Notable Quotes

Logistics comprises the means and arrangements which work out the plans of strategy and tactics. Strategy decides where to act, logistics brings the troops to that point.

General Antoine Henri Jomini

Reduction of logistics troops is called "cutting out the fat" in press releases.

Gen Carter B. Magruder, USA

Let it be admitted that the modern technological revolution has confronted us with military problems of unprecedented complexity, problems made all the more difficult because of the social and political turbulence of the age in which we live. But precisely because of these revolutionary developments, let me suggest that you had better study military history, indeed all history, as no generation of military men have studied it before.

Frank Craven

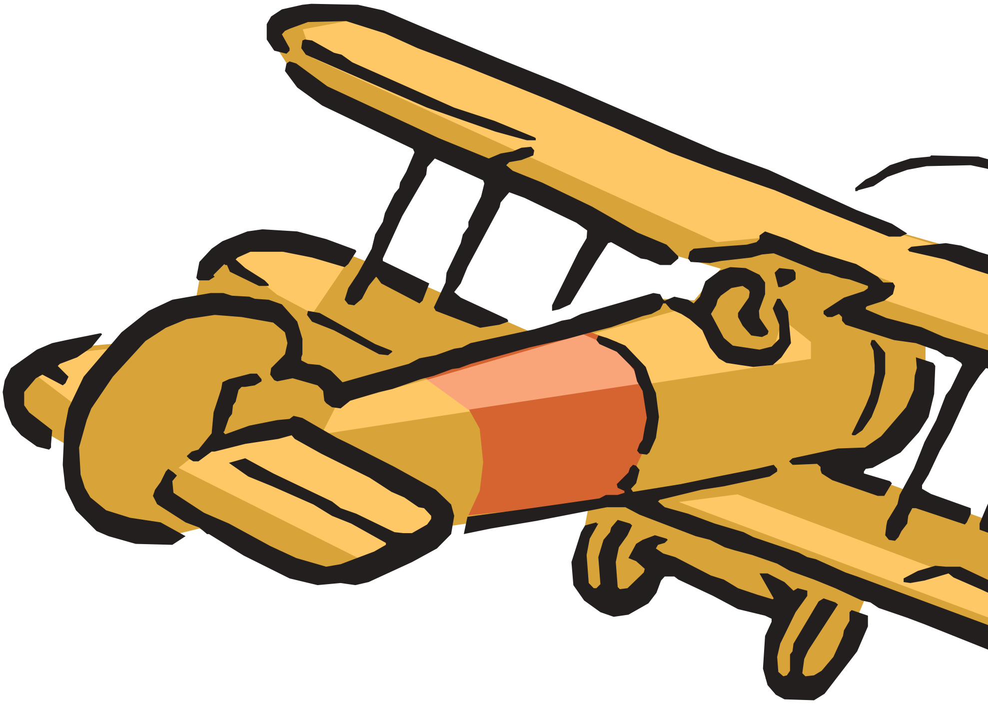
Among military matters, logistics is particularly complex. Decision should be made at those points where there is understanding, and only on the broadest logistic subjects is there understanding at a high level

Gen Carter B. Magruder, USA

The whole of military activity must relate directly or indirectly to the engagement. The end for which a soldier is recruited, clothed, armed, and trained, the whole object of his sleeping, eating, drinking, and marching is simply that he should fight at the right place and the right time.

Clausewitz

While the war raged in Europe, the US *air force* lay dormant. In 1915, the entire inventory consisted of 55 airplanes, all trainers. Of this astoundingly low number, General John Pershing, commanding officer of the Army, commented that "51 are obsolete, and the other 4 are obsolescent."



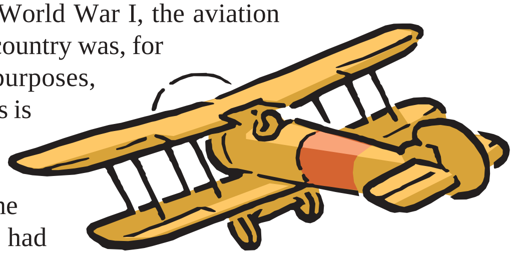
From Production to Operations

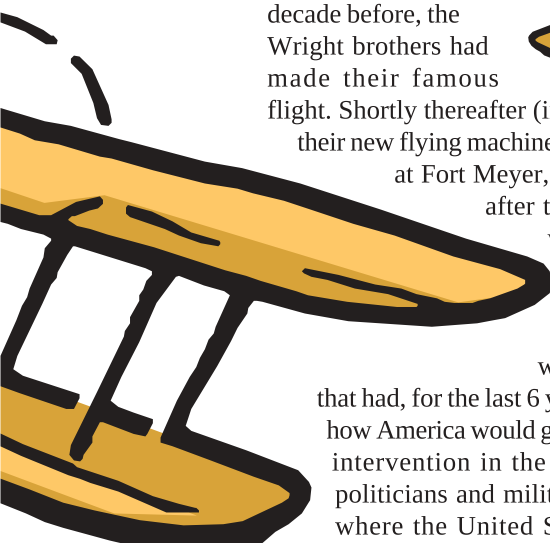
the US aircraft industry: 1916-1918

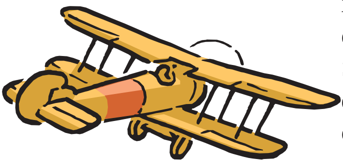
Captain Andrew W. Hunt, USAF

Introduction

It may be difficult to believe, but America's air force has not always been the best in the world. In fact, before American involvement in World War I, the aviation industry in this country was, for all intents and purposes, nonexistent. This is astounding, given that only a decade before, the Wright brothers had made their famous flight. Shortly thereafter (in 1908), they pitched the idea of using their new flying machine for military purposes to Army officials at Fort Meyer, Virginia. Momentum was strong. But after that meeting, where the brothers' idea was met with skepticism, subsequent efforts to increase the use of the airplane in a military role were minimal, at best. The outbreak of the war in 1914 did little to rekindle a fire that had, for the last 6 years, barely flickered. No one was sure how America would get involved in the conflict. As American intervention in the war became more and more likely, politicians and military leaders alike sought to determine where the United States could help the most—and the fastest. Everyone knew that the US Army would send troops, tanks, and other equipment to the front, but an opinion gaining







This article examines the state of the aircraft industry (and the associated logistics issues) before and during American involvement in the First World War.

momentum in Washington was that America might prove a more effective ally if it were to provide a combat air force to the European theater.

The role of the airplane in war had evolved quickly, from simple scouting and artillery spotting to aerial troop support and bombing missions. No longer was the airplane a novelty, it was now a military necessity. In an impassioned statement to the US Government in the spring of 1917, French Premier Alexandre Ribot urged the United States to make a sizable contribution to the production and deployment of aircraft in the European theater.[1] Seeing an opportunity to have a greater impact in the war, not only on the battlefield but also above it, the government began a renewed effort to establish a legitimate aircraft production base in the United States.

Unfortunately, the apathy pervasive in the industry meant that serious obstacles existed. Little had been done to advance the technology of the American airplane to the same level as that of the airplanes flown by other combatants. A limited production base initially proved completely inadequate to the challenge of contributing anything meaningful (in terms of aircraft production) to the war. There was no significant information base from which to draw technical expertise in the construction of these new, military-specific airplanes. And there was no prior experience available to direct and guide those in charge of managing this Herculean task. This was extremely evident in the arena of logistics. Never before had the United States had to plan for a production and movement of this size (especially for a new battlefield instrument), and there had never been an obstacle the size of the Atlantic Ocean to hinder the efforts of planners to sustain such an operation. Nevertheless, failure was not an option. The United States *had* to provide a sufficient (in both capacity and capability) air arm if the Allies were to have any increased chance of winning the war above the trenches. As a member of the newly formed Aircraft Production Board said, "The eagle must win this war."[2] Each area of logistics, from production to repair, presented relatively new challenges to the individuals in Washington and on the Western Front. In as little time as possible (roughly 14 months), an intricate system was established to deploy airplanes and then provide the battlefield logistics support necessary for the Air Service to keep the Allied skies clear.

This article examines the state of the aircraft industry (and the associated logistics issues) before and during American involvement in the First World War. The article is divided into three separate sections. First, there is a discussion of the state of the industry in late 1915 and early 1916, to include existing aircraft, facilities, and production centers. A second section examines the logistics methods used and hurdles faced in attempting an unprecedented rapid mobilization. In this section, the formation of the organizations responsible for forming the Air Service is mentioned briefly. The majority of this section, however, focuses on the trials and tribulations of actual aircraft production, specifically the American version of the British De Haviland (DH)-4. From raw materials to finished goods, the generation process of a satisfactory aerial platform was expensive, untested, and time-consuming. As aircraft were needed in large numbers in minimum time, this process is worth investigating. The lack of an existing infrastructure in the airplane industry meant the production process had no prior model. The third section of the article focuses on the planning and construction of the Liberty engine. Like the DH-4, the production of this powerhouse required logistics efforts unseen prior to 1917.

The *Air Service* Before the Americans Entered the War (1915-1917)

While the war raged in Europe, the US *air force* lay dormant. In 1915, the entire inventory consisted of 55 airplanes, all trainers. Of this astoundingly low number, General John Pershing, commanding officer of the Army, commented that "51 are obsolete, and the other 4 are obsolescent."[3] Even though the primary need for airplanes was for trainers, it was surprising that the inventory did not include a single combat (bomber or pursuit) plane.[4] (While there were aerial operations in the Mexican campaigns, none was considered a combat mission; airplanes flew observation missions in support of the soldiers on the ground.)

While the aircraft situation before the United States entered the war was dire, few options were available to correct this problem.

Additionally, the military possessed and operated only two dedicated flying fields: one in Texas and one in New York.[5] In terms of personnel, the Air Corps was just as lacking. Of the 131 officers in this branch of service, only 26 were considered *fully trained*, and not a single member of the US military "had actual combat flying experience."[6]

While the aircraft situation before the United States entered the war was dire, few options were available to correct this problem. In 1915 and 1916, the Curtiss Company was the lone company capable of contributing anything substantial in terms of airplane output. Curtiss was already producing 100 training planes per month for the British.[7] Within a year, the number of contractors the government employed to build airplanes increased to nine companies, tasked to produce 366 planes (of which only 64 were ever delivered).[8]

American Aviation Prepares for War

In late 1916, it was apparent that the United States would soon be a major participant in the war in Europe. As such, it would send its army to fight alongside the British, Italians, and French. But its contribution would not be limited to the role of the foot soldier. With louder and louder voices, the Allies embroiled in the conflict across the ocean urged the United States to contribute a sizable air arm. As the United States was the pioneering nation in the frontier of flight, this was hardly unreasonable. However, as mentioned earlier (and a statement that will be a recurring theme), the apathy in American aviation made this request a difficult one. Before 1917, US civil aviation activities were not at a level that could be considered significant.[9] "America, with the apathy of peace, had been outdistanced by the billigerents in the science of aviation."[10]

Formation of National Committee on Aeronautics and the Aircraft Production Board

The first signs of life in the military aviation sector surfaced in late winter of 1917. On 5 February, officials in the air arm of the army decided to prepare an initial estimate on the aviation requirements needed to support an organization of regulars, volunteers, and the National Guard. Initial dollar amounts neared a staggering $49M.[11] Again, the capacity of the industrial sector to handle these requests was unknown. In the first few months of 1917, the number of contractors employed by the government stood at 11, and nearly 300 planes were on order.[12] For the first time, thought was given to managing the production and acquisition of these materials. The National Committee on Aeronautics was established in March 1917; its mission was to bring together the manufacturing sector and the government since there was a noted "lack of cohesion."[13] This organization was designed to prevent duplication of efforts and keep costs under control. The committee, headed by noted paleontologist Dr Charles D. Walcott, recognized the absolute lack of airplane manufacturing capability and suggested, to speed up production and mobilization, a standardized training plane for use by both the Army and the Navy be adopted as soon as possible.[14]

In April 1917, the government formed the Aircraft Production Board to oversee the production plans and projections for the Army aviation sector.

In April 1917, the government formed the Aircraft Production Board (APB) to oversee the production plans and projections for the Army aviation sector. This organization was the focal point for all military aircraft production and was solely responsible for ensuring that the United States could field a viable air contingent. Headed by Howard E. Coffin, an automobile manufacturer from Detroit, the APB began its crusade on 12 April (6 days after America formally entered the war), with the announcement of a 3-year production plan: 3,700 aircraft in 1918, 6,000 aircraft in 1919, and from 9,000 to 10,000 aircraft for 1920.[15] Initially, the main focus of the Board was the production of trainers. The rationale behind this decision was that there was little or no knowledge of battle planes in this country and that the gathering of information over the next 6 months (April-October 1917) from the Allies would slow production to the extent that the output realized by manufacturers would be of little use in the war effort.[16]

Since the airplane production sector was so far behind, the APB proposed a deal with the French that would allow the military to make a more immediate impact in the air war in Europe. In May 1917, the United States proposed a

After this initial requirement, Ribot requested that there be 2,000 planes and 4,000 motors built in the American factories each month until early 1918.

16,500-ton shipment of men and materials to France in exchange for airplanes, motors, and land for airfields.[17] In August of the same year, the deal was revised to read that France would send 5,000 planes and 8,500 engines in return for tools and materials.[18] This deal seemed feasible, as the United States had greater quantities of human and materiel resources, while the Allies had a greater capability to produce combat-ready aircraft.[19] This early reliance on the French would be a pervasive theme throughout the war.

American Intervention Requested

In the summer of 1917, the French and British governments applied the most direct pressure to the American aviation sector. In a meeting between French Premier Rene Viviani and Britain's Lord Arthur Balfour, the common sentiment was that the United States could do more to help the Allied effort by "sending a powerful air force to the Western Front in time to participate in the 1918 campaign."[20] Soon after that meeting, a statement issued by Premier Ribot on 26 May urged the United States to furnish a flying corps of 4,500 aircraft, 5,000 pilots, and 50, 000 mechanics. After this initial requirement, Ribot requested that there be 2,000 planes and 4,000 motors built in the American factories each month until early 1918.[21] Ribot's request may have had some extreme outside influence. It is rumored that the impetus for this proposed plan may have come from Lieutenant Colonel William "Billy" Mitchell.[22] Amazingly, these requests were deemed by the Aircraft Production Board to be attainable.

Many people echoed the sentiments for American air involvement. Secretary of War Newton Baker said that the formation of an air arm "seems …the most effective way in which to exert America's forces at once in telling fashion."[23] Orville Wright, still an active participant in the aircraft industry, commented that if the Allies have a sufficient number of airplanes to keep the enemy planes back, and their "eyes can be put out—it will be possible to end this war."[24]

Now that a crude production schedule was in place, the military began to tackle the immense logistics effort required to support this massive mobilization. Not only were the engineers and manufacturers under a severe time constraint, but there was also no experience in the production of combat planes to make this process any easier. Unfortunately, for the United States, the Army had not sent observers to Europe to get the necessary technical information for the construction of these aircraft.[25] "Much of it [the project] had to be drafted in the dark," and there was a "supreme need for haste."[26]

The journey of aircraft production began on 24 July 1917, with the passing of the Aviation Act in Washington. This legislation provided $640M (although this number would decrease dramatically in the coming year) for research and design, supplies and manufacturing, and procurement of airplanes.[27] The initial projections for having 2,500 operational, domestically built aircraft by 1 January 1918 available for training were deemed "totally within reach…and immediate efforts were taken to build 500 training machines."[28]

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Obstacles to Initial Production—Inexperience and Raw Materials

The ability of a nation to produce and procure materiel is key to supporting military operations. General Carter Magruder, a prominent army logistician, noted that, for a nation to be successful in a military campaign, its domestic production must be equal to the expected consumption in all theaters.[29] James Huston, a noted military historian, added that, in the realm of production and fielding of new weapons of war, there are concerns in the production sector. He observed that a new weapon (or piece of equipment) may incur "delay(s) in production," and experience supply difficulties. Put these two thoughts together, and it's clear that building an air force from scratch was going to be extremely difficult.

Perhaps one of the biggest obstacles facing the military in the pursuit of airplane production was the lack of experience in the logistics arena. No one involved had any appreciable expertise in this area, and the events that transpired in late summer of 1917 brought this fact to light. The lack of experience nearly derailed the initial efforts of the Army to field a viable air arm before it even began. Other American industries had benefited from the early years of the war. The Allies had turned to the United States

The WW I airplane was constructed mainly of wood and linen held together by a series of wires, stitches, and adhesives.

for assistance in the supply of ammunition (among other things), but they never asked for help in producing airplanes.[30] As a result, the airplane industry was nowhere near capable of responding to the initial requests, and even the work done since America entered the war had been "wholly inadequate."[31] The procurement of raw materials for aircraft production was a huge roadblock that faced the men responsible for building these machines. This issue would prove costly and difficult.

Raw Materials

Raw materials are the first key to production and, therefore to any logistics operation. Huston notes that the availability of raw materials for an item (and the subsequent ease of production for that item) is as important as the battlefield performance of that item.[32] Little thought was given to the fact that the lack of any material, whether major or minor, could lead to the grounding of any production process. As one observer noted, "no one ever thought that the production programme…could be held up by the lack of small items, such as acetate lime for aircraft doping."[33] To ensure the availability of these necessary materials, the government decided that intervention was necessary. The government decided that it must manage and finance these different industries.

The WW I airplane was constructed mainly of wood and linen held together by a series of wires, stitches, and adhesives. The wood used in the production of the airplane had to be lightweight, as the power of the available engines was not sufficient to lift much weight. At the same time, the wood had to be flexible and durable to withstand the poundings administered by both the wind and the ground (landings could be quite rough). Engineers determined that spruce would be the best wood, as it was the "toughest of the softwood."[34] The difficulty facing the government was the collection and processing of this raw material and its delivery to the necessary production plants. The spruce reserves were located in the remote forests of the Pacific Northwest. Access to that area was limited as the roads were often impassable. The government embarked on a large lumberjacking operation, sending approximately 15,000 troops to harvest the valuable wood in the forests of Oregon.

This was an unplanned deployment, as no one could have predicted that troops would be used to collect raw materials.

Since spruce was deemed perfect for aircraft production, the government sought to keep it out of the hands of the Central Powers, and the APB announced that "all spruce would be bought by the government."[35] Here, the government exercised its right to act in the interest of national security by basically monopolizing the spruce industry, setting the price that the loggers and lumberjacks could charge per long ton of wood. The spruce was milled (using roughly 4.5 percent of each tree cut—try getting away with that today) and sent by truck to the production plants for further refinement to make it suitable for airplane usage.

In 1918 alone, the Air Service requested nearly 10 million yards of linen and 204,000 gallons of aircraft dope. The production of these materials was already at the maximum levels available. "Supply could not be increased by existing plants nor by building new plants" due to the lack of precious wood.

Obviously, wood was a main concern, but the availability of linens (for wings and fuselages) and dopes (a material used to coat the wings to render them flame-resistant, waterproof, and tight) was also in question. The need for these two materials was immense. In 1918 alone, the Air Service requested nearly 10 million yards of linen and 204,000 gallons of aircraft dope. The production of these materials was already at the maximum levels available. "Supply could not be increased by existing plants nor by building new plants" due to the lack of precious wood.[36] Another example of the shortage of raw materials was the lack of castor oil, a lubricant used in aircraft systems. To combat this problem, the United States actually imported castor beans from Asia to seed farmland in this country, thereby creating raw materials.[37] The process of collecting, transporting, and processing these resources was an important hurdle facing the government in 1917. Even with the active participation of the government, many asserted that "satisfactory aviation material would not be available until 1918."[38]

Aircraft Production

As mentioned earlier, when the United States entered the war, the initial need for domestic aircraft production was solely to fill the requirement for training aircraft. The Curtiss Company and the Standard Aero Company, with the production of the JN-4 *Jenny* and the SJ-1, respectively, *The real challenge rested in the ability of the American industry to produce combat-specific aircraft in a short enough time to make them available for the 1918 campaign.*

adequately fulfilled this need. However, the real challenge rested in the ability of the American industry to produce combat-specific aircraft in time to make them available for the 1918 campaign. At the time, there were four major problems facing the United States in this venture. First, there was no existing knowledge of battle planes or their construction. As noted earlier, the US inventory did not have a single battle plane at the time the United States entered the war. Arthur Sweetser said, “At the outbreak of the war, no one in this country had any knowledge of what a battle plane was.” Second (again a prevalent theme), there was a shortage of any appreciable manufacturing and engineering facilities, and capacity prohibited the advancement of airplane technology. Third, the United States was geographically removed from the fighting, which prevented both timely communications and the expedient flow of information with the combatants on front. Finally, no one in the industry was prepared to handle the intricate nature of the problems that would undoubtedly surface with the employment of these new machines.

Specifically addressing the first area of concern, the government sent observers to Europe to obtain the necessary technical data to begin construction of the airplanes. The representatives, led by Major R. C. Bolling, arrived in Europe nearly 3 months after the United States entered the war. As a result, combat aircraft production efforts could not begin until early summer of 1917.[39] Still, the entire production process would be trial and error, with most improvements made after “bitter experience and disappointments.”[40] The lack of manufacturing, distance from the front, and inability to solve technical problems all surfaced in the determination of what planes the United States would actually produce.

Originally, the military decided that the construction of combat planes would focus on an American redesign of the immensely capable and extremely popular Spad fighter. However, the life of the single-place (single seat) plane produced in the United States was short-lived. On 15 December 1917, Pershing ordered that production focus on a two-seat variety of airplane and that the production of the single seat planes be left to the Europeans.

Subsequently, the reproduction of the Spad was canceled.[42] The military then decided that the British DH-4, a daytime reconnaissance and bomber platform, was to be the focal point of the American Air Service and its production efforts.

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The production of the DH-4 was delayed until August 1917, since a model had not yet reached the United States. The model arrived in Dayton, Ohio, on the 26th of the month, and was available for use as a basis for production.[42] The production facilities housing the DH-4 operations were literally built as the plane was constructed. In 2 months, the first DH-4 was rolled off the assembly line and made its first test flight on 28 October 1917. Powered by a Liberty engine, the plane passed all initial tests and was now ready for mass production.

After the successful test flight of the DH-4, the APB awarded a contract for 2,000 aircraft to the Dayton-Wright Company. Initial projections for aircraft production showed that 1,475 aircraft would be ready by 3 January 1918. However, nearly 3 weeks after that projected completion date, the DH-4's production life had just started. The problems of production were not due to a lack of raw materials, as government assistance ensured the requirements were met, but to the continued lack of experience and technical knowledge in the area of production. (The manufacturing processes used in the United States were markedly different than those used in Europe. The United States mastered the assembly line technique, best suited for items that could be made the same way over and over again. In Europe, the production process was highly specialized, where each item was manufactured in whole, one item at a time.)

It was not until 5 February 1918 that the first operational DH-4 aircraft left the Wright plant and arrived in Hoboken, New Jersey. On 15 March, the aircraft was packed aboard a steamer destined for France.[43] On 8 April, the first US-built DH-4 arrived in France. Nearly a month later, the aircraft flew its maiden voyage, armed as a combat plane should be. Although the results of the test flight were deemed satisfactory, certain changes had to be made to the airframe, which further slowed production and deployment. Specifically, the munitions stations on the

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aircraft were of British design and were not capable of holding US ammunition. New bomb racks were needed. These were easy corrections, and by the end of 1918, the DH-4 was in "appreciable production."[44] A fully-armed DH-4 consisted of two .30-caliber Marlin machineguns in the nose and two .30-caliber Lewis machineguns in the rear, plus 220 pounds of bombs. By the spring of 1919, it was a viable aerial addition to the Allied efforts. The production rate of the DH-4 was unrivaled for the time period. Said Secretary Ryan, "We built more airplanes from month to month from the time we began than any other nation in the war built from the time it began."[45]

While mass production of the DH-4 was ultimately successful, aircraft production in the United States included other efforts. The government redesigned both the Italian-designed Caproni heavy bomber and the British Handley-Page bomber. Three Capronis were ultimately assembled, while the Handley-Page never progressed past the prototype stage until after the war.

The Liberty Engine

Although the DH-4 is a remarkable example of time-constrained manufacturing of an unproven commodity, the simple fact is that a plane will not fly without a powerplant. In fact, the size of an air force is contingent upon how many quality motors it can acquire or produce.[46] Coinciding with the development of the combat airplane was the aggressive production of the Liberty engine. So named to represent the principle by which it was constructed, the Liberty engine was the shining achievement of American industry during World War I. The Liberty's road was not smooth, as the same pitfalls that slowed production of the DH-4 were also present in the engine-manufacturing sector. At the time of American intervention, four separate manufacturers were capable of building and had built airplane engines. However, since there were no combat planes in the US arsenal, all engines previously constructed were used for training planes only. Therefore, they lacked the power and lightweight characteristics required for use in bombers and pursuit planes. The major challenge, then, was to accomplish two goals: (1) enable the existing manufacturers to increase their capacity to a sufficient level that would allow them to continue producing these engines to meet the growing need of the aviation training program and (2) require the manufacturers to design and build an engine capable of supplying the necessary power to lift the heavier aircraft. By the end of 1917, the first part of the challenge was met. The Curtiss OX5 and the Hall-Scott A7A were produced in sufficient numbers to meet all training requirements. The second part of the challenge would be more difficult to accomplish.

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Since an engine takes nearly twice as long to roll through production as an airplane, it is no surprise that brainstorming designs for a new engine occurred shortly after the United States entered the war. In May, designers and engineers met in Washington DC, determined to leave with the plans for a new, standardized motor. Unlike their decision to redesign the DH-4, the government decided that this engine should be domestically designed and produced, as the design differences among engines would not be easily reconcilable. The goal for this new motor was to remedy all repair problems overseas by using a set of standardized, interchangeable parts, while allowing for a marked increase in horsepower over models already available. After only 4 days in Washington, the plans for the Liberty motor were completed. The motor was to be an 8-cylinder, capable of producing 400 horsepower. Of utmost importance was that the Liberty would have a single stream of spare parts to facilitate the inevitable repair needs overseas.[47]

In determining who would build the motor, the government turned to the automobile industry, which had the existing technology base to begin the task. Lincoln, Packard, and Nordyke and Marmon were selected for the contract, which was awarded on a cost-plus basis; the contractor would be reimbursed for their costs, plus some portion for incentives.[48] The first engine was assembled at the Packard Plant in Detroit and sent to Washington for testing on 3 July 1917. Shortly thereafter, the development and testing of a 12-cylinder version of the engine, designed to better fit the DH-4 aircraft on the production lines, were completed.

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As promising as the future of this new engine was, there were still major problems in the production process. As with the DH-4, the projections on production for 1918 were overly optimistic, and the production dates were pushed back repeatedly.

with the DH-4, the projections on production for 1918 were overly optimistic, and the production dates were pushed back repeatedly. The plan was to have more than 9,400 motors produced by the beginning of June 1918. In actuality, the number available by the end of May 1918 was a little more than 1,100.[49] These problems in production resulted from (as in the aircraft industry) the total inexperience in the manufacturing of this type of machine in both large numbers and in a short time. Those in Europe believed the American method of standardized production could not be applied to the construction of a precise instrument such as an airplane engine.[50] Interestingly, the construction of the airplane engine placed more demands on the manufacturers than did the automobile engine. Manufacturers were forced to expand their capacity (facilities and so forth) to handle these demands.

Manufacturers had to design new machines and tools to build the engines. This took time. In addition, obtaining materials for the production of this engine was not easy. The Liberty 12 was roughly 25 percent lighter than a 12-cylinder automobile engine, so the materials needed for construction of the Liberty were different than those found in the typical automobile of the day.

Despite these roadblocks, production of the Liberty engine reached 15,572 engines by the end of the war, with production reaching an astounding rate of 150 engines per working day at the height of production.[51] The engine was popular with the Allies, as it possessed more power than any other aircraft engine available in the theater. As such, the demand for Liberty engines was "far greater than the Air Service's demands alone."[52] Italy ordered 3,000, the British ordered 300, and France requested a number of engines as well. In terms of raw numbers at the time of the armistice, the production of the Liberty engine has "never been remotely touched in the production of any like complex mechanism."[53]

Transportation

While the production developments of the DH-4 and the Liberty engine were of paramount importance, logistically speaking, nothing can lose a war faster than inadequate transportation. Without the means to get the raw materials from the source to the manufacturers and likewise the finished product overseas, all the efforts by the industrial sector would not matter. It is likely that the transportation infrastructure of the United States was never tested as it was from 1917 to 1918.

The government realized quickly that transportation must be made available and that those resources were scarce in the country already. As the production tempo increased throughout 1917, the means of transporting aircraft, engines, men, and materiel had to be made accessible. Therefore, in December 1917, the War Department established the Inland Traffic Service. This organization immediately seized the existing railroads and designated them for war use only. [54]

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Domestic transportation was only half the challenge facing both the airplane and engine manufacturers and the military. Timely delivery of the planes and the materiel to support them was still unproven. Ocean transportation was the lone option, and in a resurfacing common theme, the United States lacked the capacity for this logistics area. Also, the United States had never attempted to ship instruments as complex and delicate as these new planes and motors. Whether or not they would stand up to the rigors of transoceanic shipping was unanswered.

In 1916, the United States accounted for less than 6 percent of the world's 35 million tons of shipping (in terms of vessels).[55] Efforts were made to charter merchant marine ships to increase the shipping capacity of the United States. It was not until 3 years into the war that the United States chartered seven ships in the fleet dedicated to the movement of materiel. By the end of the war, the maritime transport fleet was capable of shipping 2,310 deadweight tons.[56] The initial lack of tonnage not only hindered the delivery of aircraft and engines to the European theater but also complicated domestic port operations. The major ports of embarkation (Hoboken, Brooklyn, and Newport News) were choked with materiel waiting to be shipped, often with no ship to haul it. As a result, US reliance on foreign shipping was prevalent throughout the war. These port facilities ran at or near peak capacity throughout the war. From August 1917 to the cessation of hostilities, *The prewar environment seriously hindered the initial mobilization of the aircraft and engine production industries.*

nearly 2,000 tons of various materials left American ports daily in support of the war effort.[55] Tonnage shipped to support the aviation corps in Europe totaled 61,000 short tons. Not included in this total are the quartermaster and engineer supplies used by the aviation corps (to include clothes, food, rail improvements, and others).

Summary

The prewar environment seriously hindered the initial mobilization of the aircraft and engine production industries. According to established logistics principles, the initial industrial capacity of a nation is one key to conducting successful operations. At no time before the war did the United States possess the required reserves needed to supply an air arm until the production in this country reached adequate levels. This lack of reserves prohibited more timely entry into the conflict, as there were no means from which to fill "unforecasted theater requirements." In addition, the initial planning for production was far too idealistic to be feasible, given that there was little or no prior experience in this field of manufacturing. From a planning standpoint, the ability to determine what equipment was needed to fill existing (or planned) requirements was immature, as the planning for such operations was late in coming. Even as the production of both aircraft and engines improved, the level of production reached the level of consumption only at the tail end of the conflict.[58]

The domestic transportation system was vital to the success of the US mobilization and deployment of the Air Service in an efficient manner. In 1917, the domestic transportation system in the United States was entirely adequate for supporting the mobilization effort. A nation's transportation system is key in determining the ability of a nation to conduct efficient operations. If the transportation system can be developed, or is in place to support the necessary force requirements, then the rest of the logistics system can be brought in line in time to be of value.[59] While the logging operations in the Pacific Northwest encountered problems in road conditions and weather, the ability of manufacturers to send the finished goods to the ports was, on the whole, satisfactory. The government's involvement in railroad operations (the Inland Traffic Service) provided the military with the means to transport large amounts of men and materiel in a timely manner. Overseas shipping capabilities lacked, initially, but were soon made sufficient through appropriation of a larger fleet and international cooperation. By the end of the war, the techniques used to deliver troops and cargo were among the best available.

Even as the production of both aircraft and engines improved, the level of production reached the level of consumption only at the tail end of the conflict.

Notes

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Shaping Logistics—Just-in-Time Logistics

Geostrategic, economic, and technological changes will make support of air operations, both at home and overseas, increasingly dependent on the flexibility and responsiveness of the military logistic organization. This requires the creation of a highly integrated and agile support chain with global reach. The most promising strategy to achieve these aims is based on a joint management approach, teaming the public and private sectors, under long-term partnering arrangements. While it is probable that organic military maintenance capabilities will be retained, particularly to address life-extension and fleet-upgrade requirements, the alliance partners will largely determine the size and shape of the military logistic organization as part of their wider responsibilities for shaping the overall support chain. Success will be measured by a reduction in inventories, faster turn-round times, more rapid modification embodiment, swifter deployment of new technologies, a smaller expeditionary footprint, lower support costs, and greater operational output.

This strategy requires more, however, than the application of just-in-time principles. It embraces commercial express transportation; innovative contracting arrangements including spares-inclusive packages; the application of commercial information technology solutions to support materiel planning and inventory management; collective decisionmaking involving all stakeholders; an overriding emphasis on operational output; and most important, a high level of trust between all the parties. These changes may well result in smaller organic military repair facilities and the greater use of contractors at all maintenance levels, including overseas. Most important, it will require the military aviation maintenance organization to move away from an internal focus on efficiency and utilization to a holistic approach that puts customer needs, in the form of operational output, first and foremost.

As with any new strategy, there are risks. The fundamental building block in determining a successful partnership with industry is *trust*. As one commentator has observed, "Trust is the currency that makes the supply chain work. If it's not there, the supply chain falls apart."[1] As support chains are more closely integrated and maintenance strategies are better aligned, the more vulnerable is the logistic organization to the impact of inappropriate behaviour. In the past, the risk might have been minimized and resilience enhanced by providing duplicate or alternative in-house capabilities backed up by large inventories. This is neither affordable nor compatible with today's operational needs. In the future, therefore, the main safeguard will be the creation of an environment in which government and industry, both primes and subcontractors, can function coherently, effectively, and harmoniously.

Notes

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Air Commodore Peter J. Dye, RAF


Air Force Logistics Management Agency