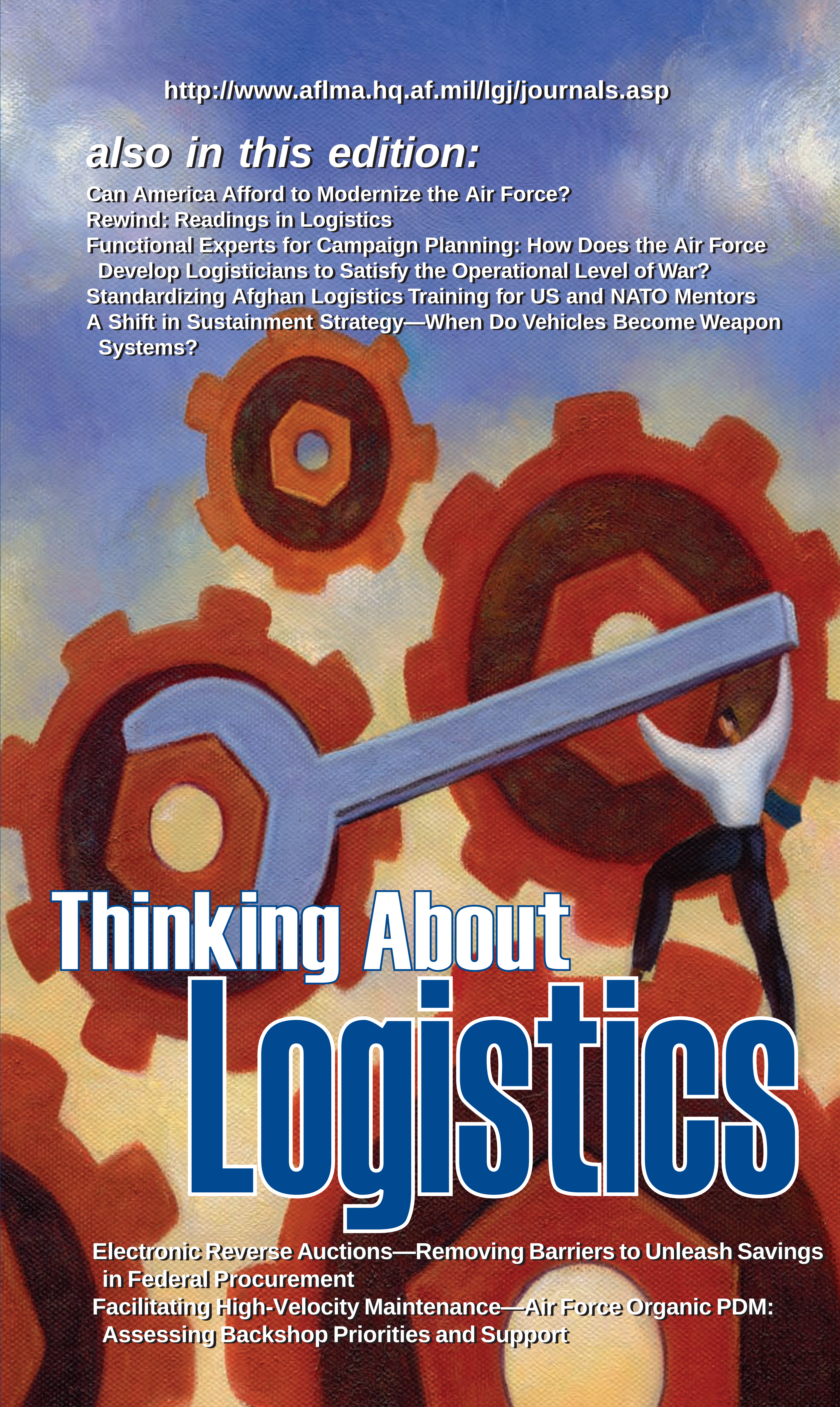

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An e-RA is an online, real-time, dynamic auction between a buying organization and a group of suppliers who compete against each other to win the business.

Perhaps no other term has invaded the vernacular and imagination of today's maintenance community more than *high velocity*. The very idea of accelerating processes and pushing aircraft through maintenance activities is at the heart of many of the key initiatives that are in work today.

Special Feature

Thinking about logistics

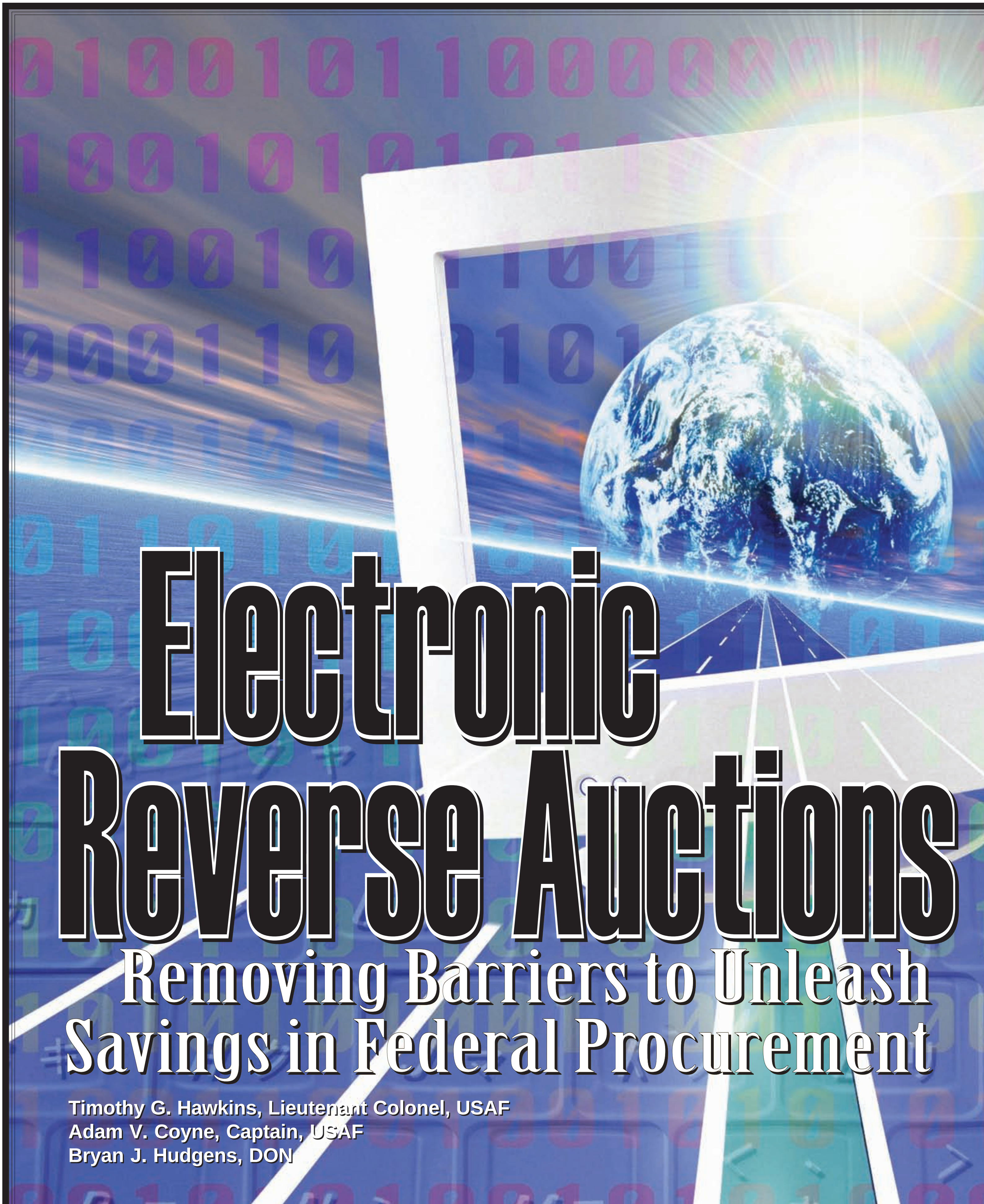
Electronic Reverse Auctions—Removing Barriers to Unleash Savings in Federal Procurement

High-Velocity Maintenance—Air Force Organic PDM: Assessing Backshop Priorities and Support

This edition of the Journal presents two featured articles: "Electronic Reverse Auctions—Removing Barriers to Unleash Savings in Federal Procurement" and "High-Velocity Maintenance—Air Force Organic PDM: Assessing Backshop Priorities and Support."

In "Electronic Reverse Auctions—Removing Barriers to Unleash Savings in Federal Procurement," the authors present a case study that explores the first and only electronic reverse auction (e-RA) conducted by the United States Air Force in Kuwait and addresses gaps in e-RA application within the Department of Defense (DoD). The research examines procedures DoD contracting officers could follow to use e-RAs for stateside and contingency procurements—and expected savings from doing so. A spend analysis of fiscal years 2007 and 2008 Air Force procurement transactions, extrapolated across the DoD, suggests the DoD is leaving billions of dollars on the table by not using e-RAs. Drawing on the results, implications for practice and recommendations are made at the conclusion of the article.

The second featured article examines high-velocity maintenance and its implementation at the depot level. Major Branson notes that there is one primary factor affecting proper execution of aircraft programmed depot maintenance orchestrated under the high-velocity maintenance (HVM) construct—scheduling chaos. The capacity to overcome unforeseen maintenance requirements is critical for HVM as the compressed time line makes such occurrences much more acute. Branson makes the point that, given the rigidity resident in the HVM process, the capacity to address such events may reside within the depot's supporting backshops.



Electronic Reverse Auctions

Removing Barriers to Unleash Savings in Federal Procurement

Timothy G. Hawkins, Lieutenant Colonel, USAF
Adam V. Coyne, Captain, USAF
Bryan J. Hudgens, DON

Introduction

Special Feature

On 17 March 2008 members of a contracting unit in Kuwait conducted an electronic reverse auction (e-RA) for the procurement and installation of 29 power generators. Over the course of 278 bids, five suppliers competed for nearly four hours before reaching the final price of $1,588,000. Shortly thereafter, the supplier submitting the lowest-priced, technically acceptable (LPTA) quote received the award in accordance with *Federal Acquisition Regulation* (FAR) Parts 12, *Acquisition of Commercial Items* and 13, *Simplified Acquisition Procedures* and the stated evaluation criteria. Savings totaled $395,000—a 19.9 percent savings from the lowest initial bid price prior to the start of the auction. Contracting personnel were praised by the media for their innovative approach and by their military commanders in performance reports.[1]

An e-RA is "an online, real-time, dynamic auction between a buying organization and a group of… suppliers who compete against each other to win the business."[2] Electronic reverse auctions essentially work "like eBay in reverse"[3] with multiple suppliers bidding down the amount they will charge a buyer for providing a good or service. The business case for e-RAs is compelling. Studies show buyers can typically save 5 to 40 percent (with an average of 20 percent) on the cost of goods and services they procure by allowing multiple bids per offeror, versus the typical one shot (or limited exchanges) currently used in government contracting.[4,5] This is important because, on average, manufacturing firms spend 55 percent of their revenue on goods and services.[6] Other benefits include the reduction of award cycle-time by up to 40 percent, increased bidding transparency, and higher price visibility.[7,8] Given these savings, it is no surprise that 31 percent of firms reported using e-RAs as one tool in their mix of strategic sourcing strategies and the trend is growing.[9,10]

In early 2000, the Department of Defense (DoD) took note of e-RA savings, investigated whether e-RAs conflict with regulations or laws governing federal acquisitions, and concluded that no regulatory or statutory conflicts precluded e-RA use.[11] Initial success prompted the Navy and Army to develop e-RA applications and policy in order to leverage industry for commercially-available, low-dollar commodities. The Air Force, however, took a different approach in 2001 by: (1) acknowledging e-RAs as a pricing tool and (2) decentralizing its use as a judgment call by individual contracting officers (CO) without providing training.[12] Consequently, Air Force COs, already burdened by the operational tempo in Iraq and Afghanistan and downsizing, rarely used e-RAs in procurements.[13] However, other federal agencies often employed e-RAs and saved millions of dollars while exceeding socioeconomic goals.[14] The variance in policy and leadership support for e-RAs suggests that the tool may be underutilized.

The purpose of our study and this article is to explore e-RA use within the federal government as a strategic sourcing tool. First, using spend analysis, we confirm the underutilization of e-RAs. Next, using the e-RA for generators as a case study, we explore how the government can integrate e-RAs into its source

Article Highlights

The DoD is failing to achieve maximum savings by limiting e-RA use to simplified, low-dollar acquisitions. Substantially greater savings are obtainable through strategically identifying goods or services in large volume in order to maximize economies of scale.

"Electronic Reverse Auctions—Removing Barriers to Unleash Savings in Federal Procurement" explores electronic reverse auction (e-RA) use within the federal government as a strategic sourcing tool. The authors, using spend analysis for fiscal years 2007 and 2008, confirm the underutilization of e-RAs. Next, using an e-RA for generators (the first and only reverse auction conducted by the Air Force in Kuwait) as a case study, they examine and explain how the government can integrate e-RAs into its source selections while easing the learning curve for individual contracting officers, maximizing e-RA use where appropriate, and saving substantial taxpayer dollars.

According to the authors' data analysis, the Air Force and Department of Defense (DoD) are leaving billions of dollars worth of savings on the table each year by not using e-RAs strategically. Analyzing spend data using two methods provides a range of potential savings of $2.59B to $25.35B for Air Force spend and $11.9B to $117B for the DoD. Even by using a more conservative benchmark, the DoD and its agencies are clearly underutilizing e-RAs. Thus, paradoxically, the government is opting out of opportunities for substantial savings at the same time it is seeking contract spend reductions of 7 percent.

The authors make the following recommendations.

- Add e-RA data collection to contract action reports and to Federal Procurement Data System–Next Generation. Capture that an e-RA was used, whether it encompassed an evaluation of nonprice factors, and savings from the independent government estimate.
- The Air Force should set goals for use and routinely track progress toward goals. Research indicates a top-down implementation approach to e-RAs is more effective than a bottom-up approach in minimizing

selections, thereby: (1) easing the learning curve for individual COs, (2) maximizing e-RA use where appropriate, and (3) saving substantial taxpayer dollars.

Congressional and executive agencies criticized the DoD for failing to take a strategic approach to improve DoD acquisition.[15] In 2003, the General Accountability Office called for "high level attention" to transform DoD's acquisition of commercial goods and services. According to the report, the broad scope of this effort should reduce purchasing costs through a more strategic approach using commercial best practices.[16] The Office of Federal Procurement Policy (OFPP) also weighed in, citing e-RAs as an industry "best practice" that maximizes competition and serves as a model to maximize DoD's return on investment.[17] This call for reform echoed earlier guidance from the Office of the Under Secretary of Defense, Acquisition, Technology and Logistics (USD/AT&L) to improve acquisition by "apply[ing] appropriate commercial best practices, [using] appropriate contracting techniques and approaches, and enhanc[ing] training" in order to "improve the effectiveness of DoD contract management."[18] Given the backdrop of business transformation and strategic sourcing, the memo suggests e-RA is one "commercial best practice" that can answer these calls for action.[19] Our research facilitates agencies meeting these calls for action by providing FAR-compliant processes explaining how to integrate e-RAs into source selections, a spend analysis that highlights potential savings from e-RA use, and a comprehensive heuristic for COs to use to determine whether an e-RA is suitable for sourcing a given requirement.

Electronic Reverse Auction Appropriateness

Electronic reverse auction appropriateness is defined as "the degree to which a sourcing professional views the use of an e-RA as a fit between the attributes of the tool, the specific requirement being sourced, and the supply market."[20] By assessing e-RA appropriateness, researchers can identify the contextual circumstances where e-RA use is more likely to lead to success of the auction.[21] Determinants of e-RA appropriateness include: specifiability, competition, leadership influence, a price-based selection criterion,[22] type of spend, expected savings, and attractiveness (purchase volume and excess capacity).[23]

Researchers point out that while price is an important factor for e-RA appropriateness, buyers can also evaluate nonprice factors (for example, delivery lead time, quality, and warranty) using a multi-attribute auction.[24] The ability to use both price-only and multi-attribute evaluations allows buyers to use e-RA for three of four types of spend. It excludes strategic spend, where the high criticality and high supply complexity of the requirement make partnerships and alliances more appropriate.[25] The other three spend categories that are appropriate for e-RA use include *noncritical* (low criticality, low supply complexity), *leverage* (high criticality, low supply complexity), and *bottleneck* (low criticality, high supply complexity).[26]

Another reason for the recent interest in e-RA appropriateness is that academicians disagree on when e-RA use is appropriate and how the improper use of e-RAs may impact the buyer-seller relationship. The concern is whether short-term savings outweigh potential long-term consequences. Some view e-RAs as a technology-assisted, power-based bargaining technique that creates distrust and invites retaliatory pricing or fails to account for the total ownership cost.[27] Others fear long-term buyer-supplier relationship erosion[28] because some suppliers feel buyers use the tool opportunistically[29] to squeeze supplier profit margins and overhead to a breaking point.[30] Because of this effect, some suppliers indicate an inclination to retaliate by seeking post-award changes or by quality shirking in order to *get well*. While these arguments are compelling, very little empirical research finds evidence to support a causal link to relationship[31] or performance degradation.[32] In the focal case study, two no-cost modifications were negotiated, the contractor completed the work on time, and the government was satisfied with the contractor's work. Nonetheless, it may be prudent for buyers to avoid using e-RAs where many post-award changes are anticipated.

Identifying Good e-RA Candidates

The e-RA appropriateness model (EAM) shown in Figure 1 should help buyers determine whether to use an e-RA to source a given requirement. Increased appropriateness should increase the odds of achieving positive outcomes such as significant savings.[33] The EAM is broken down into a series of questions in three distinct phases. Affirmative responses to each question suggest that the acquisition is suitable for sourcing via e-RA. Most questions are self-explanatory; however, two require elaboration.

If You Have a Transaction Cost Associated with e-RA Use, Will Your Estimated Savings Exceed Your Transaction Costs?

Using a potential 20 percent savings, estimate how much savings your organization stands to achieve by using an e-RA. In general, larger volumes and values increase attractiveness, which leads to increased competition and higher savings. Finally, many e-RA service providers charge a fee ranging from 1 percent to 10 percent of the estimated value of the procurement, depending on the level of service needed and their business model. Typical business models of e-RA service providers include the following.

- **Winning seller pays a per-transaction fee (percent of pre-auction estimated value of procurement)**. The e-RA service provider assists with market research, builds the e-RA in the software, trains bidders, and runs the e-RA biding event (full service option).
- **Buyer pays a per-transaction fee (percent of pre-auction estimated value of procurement)**. The e-RA service provider helps with market research, builds the e-RA, trains bidders, and runs the e-RA (full service option).
- **Software-only option**. The buyer acquires a license to use e-RA software, builds each auction, and conducts e-RAs in-house. Here, the buyer must provide training to bidders and conduct all market research.
- **Outsourced option**. The buyer contracts with an e-RA service provider for a fixed price per time period (or for an estimated number of e-RA events). For each requirement the e-RA service provider helps with market research, builds the e-RAs, trains bidders, and runs the e-RA bidding events during this time period.

Are Third Party e-RA Service Providers Available?

Table 1 shows some of the e-RA service providers. Note that providers offer varying levels of service ranging from software only to full service. A unit with a complex requirement and limited time or resources to conduct market research could benefit from the assistance of a full-service provider. The first business model above

Article Highlights

resistance from other functional areas in the organization.

- Electronic reverse auctions use should be evaluated by the Defense Contract Management Agency when conducting contractor purchasing system reviews to ensure contractors are securing fair and reasonable prices from subcontractors. Firms outsource most of their revenue to suppliers. If prime contractors are not maximizing e-RA use, then prices (ultimately passed on to the US government) are likely higher than they could be. While e-RAs force contractors to squeeze profit margins, they also force suppliers to become more efficient by reducing their operating costs.
- Each military department and each civilian agency should build the supporting structure to support e-RA use. This includes establishing an e-RA center of excellence (as is common in industry), developing and deploying e-RA training to include a DoD guide, communicating the availability of e-RA software, incorporate e-RA training through the *Defense Acquisition Workforce Improvement Act* certification process, and motivating e-RA use with incentives (promotion, recognition, future budgets). Implementing these changes should assist federal government agencies in reaping the full benefits of e-RAs.

Article Acronyms

CAPS – Center for Advanced Purchasing Studies
CECOM – Army Communication-Electronics Command
CLIN – Contract Line Item Number
CO – Contracting Officer
DIBBS – DLA-BSM Internet Bid Board System
DoD – Department of Defense
DSCC – Defense Supply Center-Columbus
EAM – e-RA Appropriateness Model
e-RA – Electronic Reverse Auction
FAR – Federal Acquisition Regulation
FPDS-NG – Federal Procurement Data System–Next Generation
FPR – Final Proposal Revision
FY – Fiscal Year
GSA – General Services Administration
LPTA – Lowest-Priced, Technically Acceptable
OFPP – Office of Federal Procurement Policy
SAP – Simplified Acquisition Procedures
SSA – Source Selection Authority

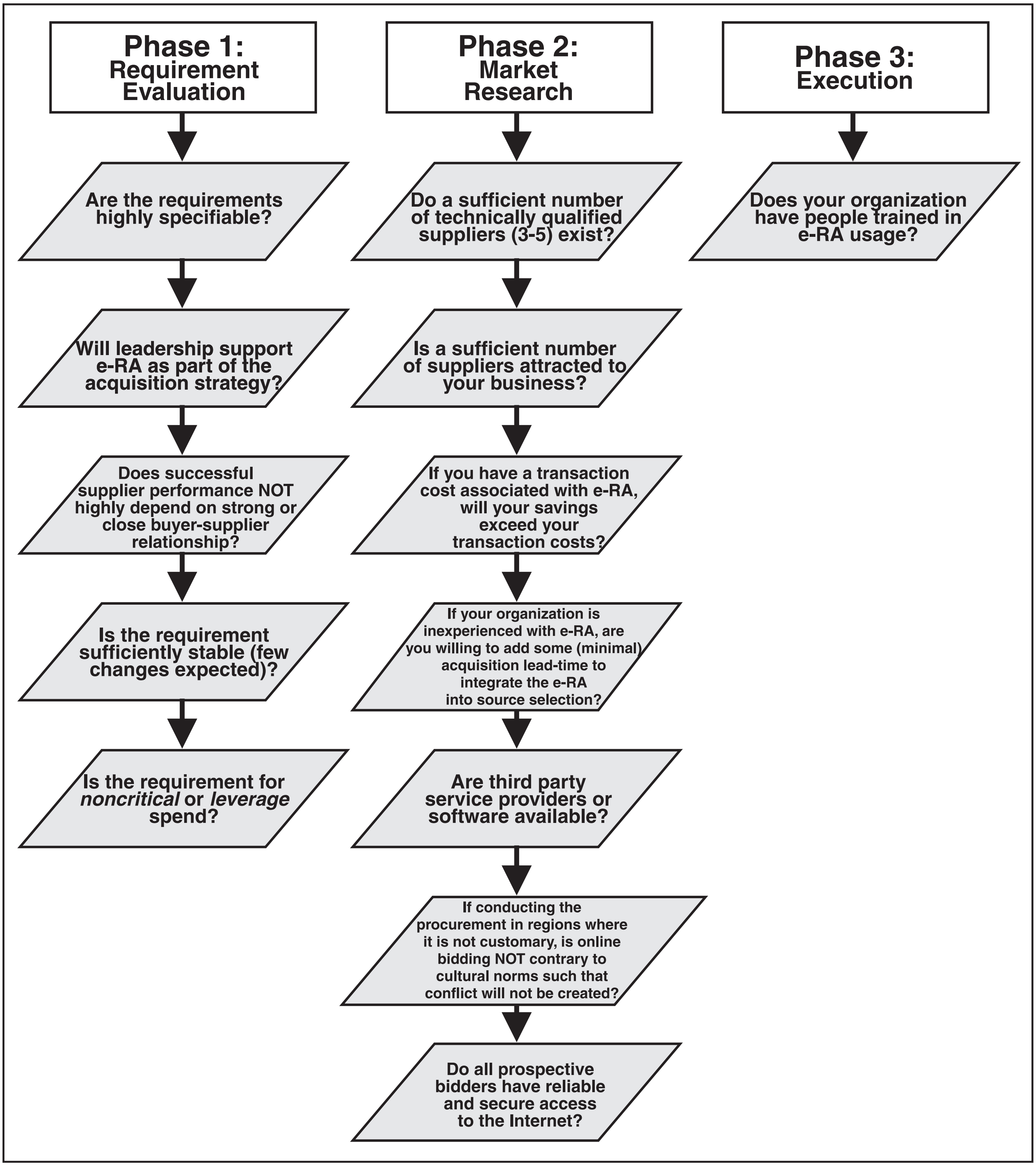


Figure 1. e-RA Appropriateness Model (EAM)

offers convenience and speed to the buyer because funding and contracting for e-RA support is not necessary. For more seasoned e-RA users, the Army Communication-Electronics Command's (CECOM) no-cost software or Ariba's sourcing tool (also no cost) might suit their needs better because experienced, available in-house COs will have the requisite knowledge to build the e-RA, conduct market research to find and build interest in the supply base, train offerors on use of the tool, and conduct the bidding event.

DoD's Use of e-RAs

Attracted by success in the commercial sector, the US Navy launched the first federal e-RA with the assistance of a third party, commercial e-RA provider in May 2000. That same month, CECOM launched two e-RA events of its own. The results were compelling. The Navy saved 28 percent, totaling $830,000, while CECOM netted savings of 20 percent and 50 percent respectively.[34] In September 2000, the General Services Administration (GSA) launched an e-RA platform of its own called Buyers.gov. Over the following three months, 212 events were conducted, with one buy saving $2.2M on a procurement valued at $10M.[35] Around this same time period, the Defense Supply Center-Columbus (DSCC) launched its own e-RA application called DLA-BSM Internet Bid Board System (DIBBS) to target acquisitions less than $25,000. Besides the typical 20 percent cost savings,[36] DSCC officials observed an 84 percent lead-time reduction—from 87 days to just 14.[37] By August 2000, DIBBS awards exceeded 4,500 contracts.[38] Currently, both CECOM and the Navy offer e-RA services to their commands. Table 2 shows how civilian agencies have experimented with e-RA use as well.

Despite cost and cycle-time savings available from e-RAs, the DoD has not set uniform e-RA policy, goals, or metrics despite pressure from executive and congressional leadership to reduce costs through strategic sourcing and commercial best practices.[39] While e-RA use differs across the military services,[40] the spend analysis that follows shows that use substantially lags opportunity. Since 2000, the US Army has conducted 10,913 auctions, with a total savings of $100.7M. In contrast, data from FedBid

Provider	Email	Phone Nbr	Web Site	Level of Service
Ariba*	Contact Us Form	1-650-390-1000	www.ariba.com	Full Service
ChemConnect	Customer-service @chemconnect.com	1-832-789-9619	www.chemconnect .com	Full Service
Exostar	Saleslead @exostar.com	1-703-561-0500	www.exostar.com	Full Service
FedBid	ClientServices @FedBid.com	1-877-933-3243	www.FedBid.com	Full Service
HedgeHog	sales@hedgehog.com	1-800-208-2335	www.hegdehog.com	Full Service
iASTA	support@iasta.com	1-317-594-8600	www.iasta.com	Full Service
OnDemand Sourcing	sales@ ondemandsourcing.com	1-412-454-5550	www.ondemand sourcing.com	Full Service
Perfect Commerce	insight@perfect.com	1-877-871-3788	www.perfect.com	Full Service
Sorcity	ContactUs@sorcity.com	1-800-525-2401	www.sorcity.com	Full Service
USAAVE (US Army)	Links to help desk are on website	1-732-427-1633	https://usave. monmouth.army.mil	Software Only
*Ariba's e-RA application (self-service) is available to Federal agencies for no fee under a government contract through NAVICP Mechanicsburg and DLA (DSCP). Contact Judith Flores at DSCP (215-737-3865) to establish a user account.				

Table 1. e-RA Providers

Agency	e-RA Count	Target Price	Award Price	Savings ($)	Savings (%)
DHHS	160	$8,702,910	$7,303,318	$1,399,592	16.10%
DHS	1,789	$256,627,681	$235,435,869	$21,191,811	8.30%
DOC	67	$4,613,605	$4,239,962	$373,643	8.10%
DOE	17	$368,776	$343,954	$24,822	6.70%
DOJ	192	$14,156,306	$12,791,797	$1,364,509	9.60%
DOS	1,590	$140,986,334	$125,547,482	$15,438,852	11.00%
DOT	17	$2,408,938	$2,261,472	$147,465	6.10%
EPA	173	$4,279,334	$4,004,659	$274,675	6.40%
GSA	283	$33,074,838	$30,767,155	$2,307,683	7.00%
IAGC	216	$14,071,487	$12,506,986	$1,564,501	11.10%
NASA	31	$565,439	$492,625	$72,814	12.90%
SSA	20	$895,335	$841,087	$54,248	6.10%
TREAS	131	$7,141,771	$6,535,051	$606,720	8.50%
VA	127	$2,701,748	$2,392,352	$309,396	11.50%
Note: Figures denote e-RA usage through FedBid only.					

Table 2. Other Agencies Using e-RAs

and Sorcity indicates the Air Force has conducted approximately 315, with a total savings of $5.4M. These numbers suggest the Air Force is leaving considerable money on the table by not using more e-RAs.[41] However, nearly all of the 315 transactions were initiated and conducted by the GSA on behalf of the Air Force. While the scope of this research does not include an explanation of the seemingly low diffusion rate, probable barriers to implementation include a high operational tempo since 9/11, a lack of leadership emphasis, a lack of policy or guidance, a lack of training, a lack of e-RA awareness, structural barriers (such as lack of or unknown access to e-RA service providers and their e-RA software applications), perceived risk of bid protests, the DoD's lack of accountability for minimizing total ownership costs, and the prioritization of transforming procurement structures for strategic sourcing—efforts that have netted the Air Force $98M in cost avoidance in fiscal year (FY07).[42] Nonetheless, with such a need for cost savings, it is puzzling why a commercially mature capability like e-RA with such a substantial potential for tangible savings, and with pockets of demonstrated success, has not been pushed harder at the agency level.

Methodology

We followed Yin's case study methodology to examine the e-RA used to source generators in Kuwait.[43] We also adopted recognized procedures for conducting a spend analysis.[44] According to Yin,[45] a case study methodology is appropriate when three conditions exist.

- The type of research question is exploratory in nature and takes the form of a *what* question.
- The researcher has no control of the behavioral events being researched (cannot manipulate behaviors then measure results as in a controlled experiment).
- The focus is on contemporary events.[46]

Our research met all three of these criteria. A qualitative research design best answers: what lessons from this case may be leveraged for further e-RA use by the DoD?

The research design required us to conduct interviews with Air Force and Army procurement officials outside of the event; gather and analyze spend data; and gather regulatory, policy, and procedural information surrounding federal procurement and e-RA use and training throughout the DoD. Qualitative research combines a number of different data collection methods including archives, interviews, and questionnaires.[47] We conducted 14 interviews, and recorded and transcribed each. To ensure validity, we sent transcripts to each informant to verify their accuracy—no exceptions were noted. Informants included the contingency contracting officer, three of the bidders, one prospective subcontractor, one nonbidder, two project engineers, a staff officer from Headquarters Air Forces Central, a member of CECOM, and two e-RA service providers. We conducted follow-on interviews with two bidders in order to verify initial ideas.

We also collected archival data to include 58 e-mails; 17 contractual documents; Air Force FY07 and 08 spend data; top-level FY01 to 06 Air Force spend data; policy memos; Army, Navy, and Air Force e-RA spend data; and trend data from e-RA providers on e-RA use. The data was used to construct and validate the EAM and to understand how the e-RA was integrated into a best-value source selection.

Spend Analysis

We conducted a spend analysis to identify areas of spend that are appropriate for sourcing via e-RA, then to forecast potential savings. Our methodology entailed the following.

- Obtained Air Force spend data for FY07 and 08.
- Sorted Air Force spend data to remove categories that were not appropriate for e-RA use. Categories included all research and development (typically is not specifiable, is highly relational, and entails fluid requirements); all contract types other than firm-fixed price, fixed-price-with-economic-price-adjustment, and fixed-price-award-fee (indicators of low specifiability and fluid requirements); construction (highly susceptible to post-award changes); and all contracts not awarded under full and open competition.

From the preceding step, we estimated a typical percentage of total spend that was *auctionable* (appropriate) based on the FY07 and 08 data.

- Obtained FY01 to 09 Air Force and DoD procurement spend from the Federal Procurement Data System-Next Generation (FPDS-NG).
- Applied an average 20 percent savings to the *auctionable* (appropriate) portion of FY01 to 09 Air Force and DoD spend data.[48]

In order to maximize objectivity, we used two very different approaches to identify a range of potential savings. Method one (above) filtered out inappropriate e-RA requirements and method two applied an industry benchmark of total spend typically sourced via e-RA. According to Monzcka et al., industry sources 2.58 percent of its total purchases using e-RAs.[49] A weakness of this report, however, is that it was based on a small sample size of 17 firms. Additionally, given the 4 percent response rate to their survey, its external validity is questionable. Using the two methods, the DoD's probable, appropriate usage of e-RAs can be expected to fall within this range.

Results

Spend Analysis

Method 1. Removing the contracts described above reduced FY07 spend from $70.2B to $17.7B, leaving 25.22 percent of total spend being deemed appropriate for e-RA sourcing. Applying the same methodology, we reduced the FY08 spend from $63.6B to $16.9B, or 25.13 percent of total spend being deemed appropriate for e-RA sourcing. We then averaged both percentages to reach a two-year average e-RA appropriate spend as a percentage of total spend (25.18 percent). According to this method, on average, 25.18 percent of the total Air Force spend could be awarded using e-RAs. We then applied the two-year average to FY01 to 09 to calculate an annual amount of spend appropriate for e-RA sourcing. Finally, we applied an industry average savings of 20 percent to the e-RA appropriate total for each year, leaving a potential Air Force savings of $25.35B for FY01 to 09.[50]

Method 2. Using the Center for Advanced Purchasing Studies (CAPS) benchmark (2.58 percent), we multiplied the total spend for each year by 2.58 percent to determine an amount appropriate for e-RA sourcing, which we label as *Method 2, e-RA Appropriate Spend.* Finally, we applied the industry average savings of 20 percent to the CAPS benchmark to determine a potential savings for the DoD, Air Force, Navy, and US Army for FY01 to FY09 (see Table 3). Taking the Air Force as an example, the potential $2.59B savings are 12.88 times the actual combined Army, Navy, and FedBid savings of $201M.

Taking the two methods together, we can conservatively conclude that the potential savings for the Air Force for FY01 to FY09 was between $2.59B and $25.35B, or between $288M and $2.82B per year.

For the DoD, the total savings using method one resulted in $117B and $11.9B for method 2. By providing a range from maximum auctionable spend (using spend analysis) to a conservative estimate (using an industry benchmark), the estimates sufficiently demonstrate a significant potential for savings using e-RAs (see Table 4).

FAR-Compliant e-RA Process

According to CECOM, there are several reasons COs are not using e-RAs for more complex, best value acquisitions (pursuant to either FAR Part 12/13 or FAR Part 15, *Contracting by Negotiation*). First, simple auctions are easiest to set up and execute. Another reason is complexity, both on the side of the buyer and supplier. CECOM's US Army Auction and Valuation Engine platform has the capability to conduct multi-line auctions, as well as full trade-off auctions with nonprice factors, such as delivery schedule, warranty, and quality. To date, COs have steered away from the tool because it may be perceived that adding nonprice factors into an auction and the use of an algorithm to determine the winner may increase the chance of a bid protest. Finally, the lack of best-value e-RA experience among practitioners has resulted in a natural barrier to implementation. COs who want to incorporate e-RAs into best value acquisitions face a learning curve, perceived protest risk, and—at least initially—some added procurement lead time. For flowcharts covering other types of source selections, contact the lead author.

Therefore, we provide COs FAR-compliant processes for most types of source selections ranging from simplified acquisitions to full trade-off procurements pursuant to FAR Part 15. These flowcharts should help reduce CO learning curves, minimize protest risk, and provide guidance for implementation by explaining the e-RA-specific tasks and how they integrate into a federal source selection. Figure 2 highlights extra steps COs will need to include in their acquisitions. The following discussion describes each additional step in more detail (shaded or partially shaded). Rather than address each model separately, we focus only on the simplified acquisition procedures Lowest-Price, Technically Acceptable (SAP: LPTA) model. This model has the greatest propensity for use, entails the assessment of nonprice factors, can be used with minimal additional steps, and uses streamlined procedures in accordance with FAR Part 13.

Step 1: Thoroughly Define Requirement. An e-RA adds value when bidders share a common understanding of the required supplies and services, and can bid it at a fixed price. Additionally, the requirement should be sufficiently determined to minimize post-award changes.

Fiscal Year	Contract Dollar Pool Available	Potential e-RA Appropriate Procurements ($ Billions)	Potential Annual Savings @ 20%, Method 1	Potential e-RA Appropriate Procurements ($ Billions) Using Benchmark Method	Potential Annual Savings @ 20%, Method 2
FY01	$40,658,636,487	$10,235,811,735.60	$2,047,162,347	$1,048,992,821	$209,798,564
FY02	$47,398,465,802	$11,932,563,765.65	$2,386,512,753	$1,222,880,418	$244,576,084
FY03	$55,554,711,050	$13,985,898,506.84	$2,797,179,701	$1,433,311,545	$286,662,309
FY04	$55,047,330,757	$13,858,165,518.07	$2,771,633,104	$1,420,221,134	$284,044,227
FY05	$55,581,405,190	$13,992,618,756.58	$2,798,523,751	$1,434,000,254	$286,800,051
FY06	$62,656,276,631	$15,773,717,641.85	$3,154,743,528	$1,616,531,937	$323,306,387
FY07	$70,210,415,739	$17,707,066,849.38	$3,541,413,370	$1,811,428,726	$362,285,745
FY08	$63,636,840,892	$15,991,938,116.16	$3,198,387,623	$1,641,830,495	$328,366,099
FY09	$52,746,175,463	$13,278,849,672.81	$2,655,769,935	$1,360,851,327	$272,170,265
	Total $ Available for e-RA Use (from FY01–FY09)	$126,756,630,563	$25,351,326,113		$2,598,009,731
		FY07 e-RA Appropriate %	25.22%		
		FY08 e-RA Appropriate %	25.13%		
		AVG FY07/FY08 Appropriate %	25.18%		

Table 3. Air Force Spend Analysis FY01 – 09

Organization	Total Spend (from FY01–FY09)	e-RA Appropriate Spend (from FY01-FY09 at 25.18% of Total Spend	Potential Savings (Method 1)	Potential Savings (Method 2)
CONUS Agency Level				
USAF	$503,490,258,011	$126,756,630,562	$25,351,326,113	$2,598,009,731
USA	$788,479,482,606	$197,030,573,008	$35,279,475,857	$3,645,645,373
USN	$600,671,375,441	$151,219,018,767	$26,660,817,006	$2,732,270,422
DoD	$2,324,437,837,203	$585,177,225,516	$117,035,445,103	$11,994,099,240

Table 4. DoD Spend Analysis

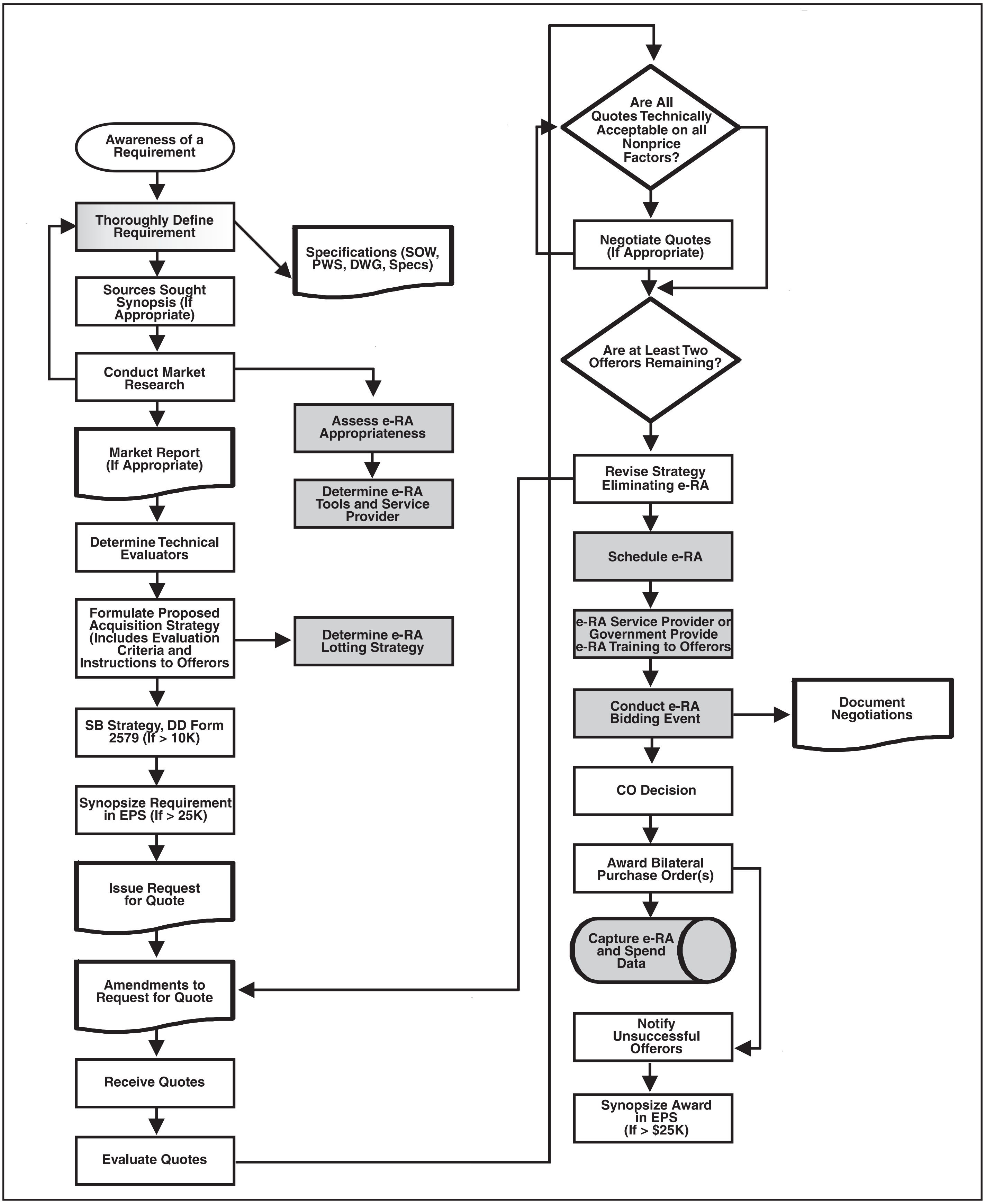


Figure 2. SAP: LPTA Process

Steps 2 and 3: Assess e-RA Appropriateness and Select e-RA Provider. Both of these steps were previously described.

Step 4: Determine e-RA Lotting Strategy. A lotting strategy, in general, allows a buyer to structure the e-RA in a manner for suppliers to efficiently bid on the requirement.[51] It resembles a contract line item (CLIN) structure. For example, a buyer may have 500 line items of supplies to place on contract and, after market research, may determine that he or she can get maximum bidding at a better price if he or she divides them into five separate groups (CLINs or bid lots). This allows suppliers to bid in subcategories that are more suited to their market niche or area of expertise while not having to bid on all CLINs or bid lots. Sometimes, awarding multiple contracts will allow the buyer to achieve the lowest total price by *cherry picking* the lowest bid from each lot and awarding multiple contracts. The key, according to Sorcity, is to balance the buyers' needs to the suppliers' capabilities. Third party providers, like Sorcity, can help identify optimal lotting strategies based on their experience with e-RAs and their knowledge of cost drivers of the requirement and cost structures of the market. In the e-RA for generators, the squadron commander conducted initial market research and determined to use a single lot because there were sufficient distributors or resellers that could provide the entire lot and multiple awards were not practical.

Step 5: Schedule e-RA. COs should schedule the date for the e-RA after negotiations on nonprice factors have concluded because negotiation time is highly variable.

Step 6: e-RA Service Provider or Government Provide Training to Offerors. It is a good idea to provide offerors training on using the bidding software prior to the event. Most e-RA service providers offer training either through a tutorial, which can run mock auctions for practice, or through hands-on training. Buyers should ensure that each bidder understands the auctioning software, the auction duration, rules regarding overtime, and how to handle contingencies during the bidding. Levels of support vary; therefore, buyers who are new to e-RAs will need to either develop their own training or ensure the e-RA service provider can provide training.

Step 7: Conduct e-RA Bidding Event. Contingencies, such as Internet interruptions, should be considered during solicitation planning and be addressed in the instructions to offerors. Simple mechanisms, such as having the provider and buyer on telephone standby to be able to place and receive manual bids, pausing the auction, and providing real-time assistance can help overcome these hurdles. Improper handling of the auction itself could result in a protest; thus, buyers need to plan for the unexpected.

Step 8: Capture e-RA and Spend Data. Capturing spend data helps provide buyers an accurate, historical database of market prices for goods and services (compared to non-e-RA prices). It also provides data to senior strategic sourcing planners for analysis, reporting, planning, goal setting, and organizational improvement.

Integrating e-RAs Into Full Trade-Off Source Selections.

Electronic reverse auctions can be integrated into full trade-off source selections by using either SAP or formal procurements under FAR Part 15. There are three different means to do this. First, different e-RA service providers' auctioning applications provide different functionality. Generally, many offer multi-attribute bidding where certain factors, such as price, delivery, and quality are assigned weights. These factors can be dynamically bid in real time where a composite score indicates the best value. Since these scores are mathematically derived, they violate some agencies' procurement policies (those that require qualitative ratings such as the Army and Air Force). While this method could be used with SAP, it would violate FAR Part 15 procedures. Therefore, it is not further discussed.

The second method entails the trade-off of predetermined levels of objective, nonprice factors and allows these varying performance levels to be bid dynamically during the e-RA. For example, a CO may need to assess the value of taking faster delivery or of acquiring higher quality. To do so would require a special construction of bid lots shown in Table 5. Essentially, the CO would need to build a bid lot (resembles a CLIN) for each possible combination of levels of nonprice factors—in this case delivery and quality. The solicitation would need to state the relative importance of price and nonprice factors. Assume for this example that, taken together, nonprice factors are as important as price. With the following lowest bids per offeror per bid lot taken from the e-RA, the source selection authority's (SSA) integrated assessment must consider these prices and performance levels.

This bid scenario from an e-RA-enhanced procurement poses no different challenge or process for the SSA than any other full trade-off source selection. The SSA must assess the value of higher performance levels traded off against price differentials (see Table 6). Here, the SSA may choose to go with basic performance levels awarding to offeror D for $415,000, or award to offeror D for $518,000 and take delivery 60 days sooner. Alternatively, if the benefit of an extra year of warranty coverage exceeds the added cost, the SSA may elect to pay a quality premium of $81,000 and award to offeror C for $496,000. If delivery and quality are valuable, the SSA may deem the best value is provided by offeror C who is the lowest with a 60-day delivery and 2-year warranty. As usual, the SSA would be constrained by the language of the solicitation as to the relative importance of price and nonprice factors and would need to justify the trade-offs. The benefits of executing this trade-off via an e-RA are the efficiency (speed and minimum effort) of negotiations in each lot (in each possible combination of performance levels) and the intense competition offered by e-RAs in each lot.

Using a third method, a CO could integrate an e-RA into a full trade-off source selection where objective performance levels and ratings are not possible. For example, if the government must (in order to manage risk) evaluate the offeror's experience or technical approach, subjective ratings are necessary. In this case, the source selection process would be nearly identical to that of a source selection not involving an e-RA. The only difference would be that after conducting all of the discussions necessary to allow offerors remaining in the competitive range to address weaknesses, risks, and deficiencies, the CO would then schedule and conduct the e-RA. It is important to note that by using an e-RA in this manner, the CO may not award without discussions. Successive bids in an e-RA held after receipt of proposals would constitute proposal revisions. Also, after the close of the e-RA, the CO must request and evaluate final proposal revisions (FPR), wherein the offeror could again alter its price—upward or downward. If, in its FPR, the offeror makes no change to its price, the offeror's last bid price in the e-RA would be the evaluated price that would be traded off with nonprice factors in accordance with the best value provisions of the solicitation.

Conclusion

The federal government has much to gain by incorporating e-RAs into its source selections. However, caution must be exercised. This research aims to ease the learning curve for COs, helping to ensure e-RAs are used prudently and only for appropriate buys. First, we identify a potentially significant cost savings that the Air Force and DoD as a whole could obtain using e-RAs. Second, we presented an EAM to assist COs in identifying requirements appropriate for e-RA sourcing. Finally, we provided a FAR-compliant process flowchart, which shows how to incorporate e-RA into federal procurements. Our process models indicate where e-RA-specific steps are needed and the elements in each step necessary to reduce protest risk and increase the effectiveness of the e-RA.

According to our data analysis, the Air Force and DoD are leaving billions of dollars worth of savings on the table each year by not using e-RAs strategically. Analyzing spend data using two methods provides a range of potential savings of $2.59B to $25.35B for Air Force spend and $11.9B to $117B for the DoD. Even by using a more conservative benchmark, the DoD and its agencies are clearly underutilizing e-RAs.[52] Thus, paradoxically, the government is opting out of opportunities for substantial savings at the same time it is seeking contract spend reductions of 7 percent.[53]

Item*	Supplies/Services	Quantity	Unit	Unit Price	Total Amount
0001	Firm-Fixed Price. Deliver and install standby generators in accordance with the attached statement of work. FOB: Destination **Delivery: 60 Days ARO. Warranty: 1 Yr**	10	EA	$_________	$_________
0002	Firm-Fixed Price. Deliver and install standby generators in accordance with the attached statement of work. FOB: Destination **Delivery: 90 Days ARO. Warranty: 1 Yr**	10	EA	$_________	$__________
0003	Firm-Fixed Price. Deliver and install standby generators in accordance with the attached statement of work. FOB: Destination **Delivery: 120 Days ARO. Warranty: 1 Yr**	10	EA	$_________	$__________
0004	Firm-Fixed Price. Deliver and install standby generators in accordance with the attached statement of work. FOB: Destination **Delivery: 60 Days ARO. Warranty: 2 Yrs**	10	EA	$_________	$__________
0005	Firm-Fixed Price. Deliver and install standby generators in accordance with the attached statement of work. FOB: Destination **Delivery: 90 Days ARO. Warranty: 2 Yrs**	10	EA	$_________	$__________
0006	Firm-Fixed Price. Deliver and install standby generators in accordance with the attached statement of work. FOB: Destination **Delivery: 120 Days ARO. Warranty: 2 Yrs**	10	EA	$_________	$__________
*Note: The government will award only one of the bid lots above in accordance with the best value evaluation criteria stated in the solicitation.					

Table 5. Bid Lots

Managerial Implications

First, the DoD is failing to achieve maximum savings by limiting e-RA use to simplified, low-dollar acquisitions. Substantially greater savings are obtainable through strategically identifying goods or services in large volume in order to maximize economies of scale. While focusing on simple commodities saves cycle time, our research indicates that contractors have more room to bargain with larger volumes.

Second, fair and reasonable prices, in many cases, are not being obtained where e-RAs are appropriate but not being used—by an average margin of 20 percent.[54] While fair to the seller, prices obtained without an e-RA are hardly fair to the buyer, and certainly not reasonable. For example, by obtaining at least two offers or quotes, COs declare their prices to be fair and reasonable; whereas, in reality, they may not be. "The mere presence of competition is inadequate to assure that the prices proposed are fair and reasonable."[55] Additionally, COs and buying activities are not held accountable for obtaining optimal, fair, and reasonable prices or costs. While acquisition professionals must secure the best value, this is a nebulous term.[56] It is true that more goes into value than price or cost alone. However, when industry procures the same or similar commercial items and services for substantially lower prices or costs using e-RAs, the government's best value determinations are, at best suspect, and at worst, erroneous.

Government buying activities are principally assessed by three metrics: contract award dollars, number of contracts awarded, and procurement lead time.[57] The *Government Performance Results Act of 1993* requires that organizations measure themselves against desired outcomes. Is price or cost performance not a desirable outcome?

> Research of the many studies conducted by the Navy indicates that the hierarchy may not be interested in how efficient a contracting office performs. Instead, it appears that they are more interested in appeasing the interests of their many stakeholders.[58]

In contrast, industry procurement activities are strictly held accountable for price and cost. Common metrics include:

> 1. Target prices—based on cost reduction goals, product and service budgets, and competitor prices; 2. Cost reduction (comparing actual prices paid in a current period to actual prices paid in a prior period); 3. Rate of actual price change to market index rate of change; [and] 4. Cost avoidance.[59] There is enormous waste in government procurements…[and] the problem is not the people, it is the processes being used.[60]

Recommendations

The following recommendations provide a way forward. First, add e-RA data collection to contract action reports and to FPDS-NG. Capture that an e-RA was used, whether it encompassed an evaluation of nonprice factors, and savings from the independent government estimate. Second, the Air Force should set goals for use and routinely track progress toward goals. Research indicates a "top-down implementation approach to e-RAs is more effective than a bottom-up approach in minimizing resistance from other functional areas in the organization."[61] Third, e-RA use should be evaluated by the Defense Contract Management Agency when conducting contractor purchasing system reviews to ensure contractors are securing fair and reasonable prices from subcontractors. Firms outsource most of their revenue to suppliers. If prime contractors are not maximizing e-RA use, then prices (ultimately passed on to the US government) are likely higher than they could be. While e-RAs force contractors to squeeze profit margins, they also force suppliers to become more efficient by reducing their operating costs. Finally, each military department and each civilian agency should build the supporting structure to support e-RA use. This includes establishing an e-RA center of excellence (as is common in industry), developing and deploying e-RA training to include a DoD guide, communicating the availability of e-RA software, incorporating e-RA training through the *Defense Acquisition Workforce Improvement Act* certification process, and motivating e-RA use with incentives (promotion, recognition, future budgets). Implementing these changes should assist federal government agencies in reaping the full benefits of e-RAs.

Future Research

The following areas could provide added value to the DoD as a buying activity or to e-RA theory in general. First, explore why

Bid Lot 0001		Bid Lot 0002		Bid Lot 0003	
Del 60/Warr 1 Yr		Del 90/Warr 1 Yr		Del 120/Warr 1 Yr	
Offer	Price	Offer	Price	Offer	Price
D	$518,000	D	$423,000	D	$415,000
B	$526,000	B	$441,000	B	$441,000
A	$533,000	C	$452,000	C	$452,000
C	$534,100	A	$455,000	A	$453,000
Bid Lot 0004		**Bid Lot 0005**		**Bid Lot 0006**	
Del 60/Warr 2 Yr		**Del 90/Warr 2 Yr**		**Del 120/Warr 2 Yr**	
Offer	**Price**	**Offer**	**Price**	**Offer**	**Price**
C	$589,400	C	$496,000	C	$496,000
D	$602,300	D	$513,000	D	$525,000
B	$610,000	A	$527,000	A	$539,000
A	$619,000	B	$540,000	B	$540,000

Table 6. e-RA Results

the Air Force has lagged other Services in e-RA use. Very few e-RAs have been conducted by the Air Force while the other branches have conducted hundreds, saving over $100M from 2000 to 2009. Researchers should explore the slow diffusion to understand better the structural barriers in place. Second, inaccurate and incomplete contract award data could be improved. During our CLIN-level analysis of FY07 and FY08 Air Force spend data, we discovered that it was not possible to accurately categorize and sort transactions into strategic *buckets* because the product service code or federal supply code data was either not entered at the CLIN level or contract writing systems are not capturing and importing the data into FPDS-NG and the Contracting Business Intelligence System. Additional research into the causes of low data fidelity could help strategic sourcing leadership conduct more accurate spend analyses.

Study Limitations

This research was not without limitations. First, the research was based on a single case study. Ideally, we would have preferred to compare responses from informants across multiple bidding events in order to increase the range, number, and depth of observations contained in the data—build credibility.[62] Still, we made every effort to increase credibility by triangulating data and by including interviews of the entire logistic chain from end users to a second-tier supplier.[63] Another limitation was the methodology we used to conduct the spend analysis. Because of the inaccuracy of CLIN-level data from FPDS-NG, we had to conduct our data analysis at the contract level. This essentially meant that large cost-type contracts may have included smaller fixed-price CLINS that were appropriate for e-RA use, but were excluded from our analysis since it was all coded as cost reimbursement. Additionally, FY01 to 06 FPDS-NG data pulls were limited to total spend because contract-level data for the Air Force, Navy, and Army was not available or accurate prior to FY07. Finally, since we could not closely evaluate every transaction, and because of the aforementioned weaknesses in the data, undoubtedly some transactions that are truly inappropriate for e-RA use were included in (and therefore inflated) the e-RA-appropriate percentage (25.18 percent).

Summary

While the e-RA is not appropriate for every transaction, our analysis indicates the DoD is leaving billions of dollars on the table by not incorporating it into larger acquisitions involving *noncritical* and *leverage* types of spend.[64] Put into perspective, using the most conservative method of analysis, the potential savings generated by e-RA use over the past nine years could have funded the following high priority platforms.

- Air Force: 65 RQ-1 Predators. Price: $40M each[65]
- Navy: 78 F-18 E/Fs. Price: $35M each[66]
- Army: 2,800 MRAPS II: RG-33s. Price: $1.3M each[67]

Our analysis sends an important message: An e-RA is a powerful tool that, if used appropriately, has the potential to increase transparency, competition, efficiency, and taxpayer savings. The tools provided herein are designed specifically to help COs overcome structural barriers including training, operational tempo, and a lack of e-RA policy and guidance. Specifically, our processes and models should help COs select appropriate requirements, contact e-RA service providers for assistance if necessary, and appropriately structure e-RAs for optimal savings, compliance with the FAR, and minimum risk. Finally, the DoD levied a $100 billion savings goal over the next five years, and the federal government has a mandate from the Office of Management and Budget (OMB) to reduce contract spend by 7 percent by FY11.[68] Further, the OMB mandated that agencies must negotiate more favorably priced contracts, implying that the government contracts at other than fair and reasonable prices and costs. Electronic reverse auctions generate, on average, 20 percent savings.[69] What if an agency could reply, "I see your 7 percent, and raise you 13"?

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Special Feature

Introduction

Continuous process improvement has become the primary means for addressing the myriad of constraints that Airmen face. The idea of doing more with less has slowly given way to doing the right amount of work with the finite capacity available. The elimination of nonvalue added work, waste, and processes redundancies has enabled workers with the ability to right-size workloads to the resources available. The latest innovation along this vein is the high-velocity maintenance (HVM) concept being tested in a pilot program at Warner Robins Air Logistics Center (ALC). This program holds great promise, but its success is dependent upon factors outside of direct program control. One such factor is depot backshop support. The responsiveness and capability of the backshop will be critical in enabling HVM to deliver the anticipated gains. The case for change, development of HVM and its principles, and overview of the depot backshop workload prioritization process will provide the framework for determining feasibility and areas of concern for mitigating backshop lag that may negatively impact HVM operations.

Driving Towards Improved Aircraft Availability

Today's Air Force has a significant aircraft availability dilemma that impacts almost every weapon system in the fleet. This problem is especially troublesome in the high-demand or low-density aircraft fleets. The increasing age of aircraft, high operational demands, reduced manpower, and overall lack of fiscal resources further compound the problem to the extent that previous solutions provided to address aircraft availability shortfalls have been found insufficient. It is within this framework that the logistics community has embraced process improvement. Given earlier successes, the community continues to build upon and stretch for even further gains as evidenced in the initial Expeditionary Logistics for the 21st Century (eLog21) goals. These goals include a 20 percent increase across the board in aircraft availability by year 2013, with a corresponding reduction of operation and maintenance costs by 10 percent.[1] Although the availability goals have since been modified to reflect actual improvements required of each weapon system, the road ahead remains challenging for all those in the logistics business.[2]

Within the logistics enterprise, the maintenance community holds the most potential for providing the greatest gains toward achieving the eLog21 availability goals. Utilizing a myriad of AFSO21 tools from Lean to value stream mapping, maintainers have already provided incremental success that span all levels of the Air Force. At the unit level, gains are being made little by little, and perpetuated throughout the Air Force. MacDill Air Force Base's 6th Maintenance Group is an example where initiatives implemented locally reduced each KC-135 aircraft turn time by 30 minutes, freeing up an estimated three to four aircraft per week for additional missions.[3] Other initiatives have gone well beyond base level and have altered the entire outlook of an aircraft fleet. Air Mobility Command's regionalization of

Richard W. Branson, Major, USAF

High-Velocity Maintenance

Air Force Organic PDM: Assessing Backshop Priorities and Support

Article Highlights

Today's Air Force has a significant aircraft availability dilemma that impacts almost every weapon system in the fleet. This problem is especially troublesome in the high-demand or low-density aircraft fleets. The increasing age of aircraft, high operational demands, reduced manpower, and overall lack of fiscal resources further compound the problem to the extent that previous solutions provided to address aircraft availability shortfalls have been found insufficient.

Continuous process improvement is considered by many as the best means for addressing the problem of meeting seemingly unlimited demands with finite resources. As the idea has matured within the Air Force, it has taken on a personality of its own in becoming AFSO21. Even with its formalization, the myriad of process improvement initiatives being undertaken throughout the Air Force remain mostly localized and limited in scope. One of the few examples of process improvement that strives to break out from mainstream is the high-velocity maintenance (HVM) pilot program that is being adapted to programmed depot maintenance operations at the Warner Robins Air Logistics Center. The success of this concept will rely heavily on factors currently outside of the center's control as well as difficult adjustments within its own organizations. If proven, the concept will serve as a good example of how process improvement can be accomplished on a vastly larger scale and may serve as an informative case study on process reengineering organic operations.

There is one primary factor affecting proper execution of aircraft programmed depot maintenance orchestrated under the high-velocity maintenance construct—scheduling chaos. The capacity to overcome unforeseen maintenance requirements is critical for HVM as the compressed time line makes such

C-5 isochronal inspections is one such success story where productivity, quality, preventive maintenance, economy of scale, and aircraft availability all trended in positive directions. The bottom line on the efforts was the dramatic reduction of the maintenance cycle from an average of 25 days to 14 directly resulting in 407 additional days of C-5 availability per year.[4] Even broader is the Repair Network Enterprise program which seeks to leverage global visibility of all repairable assets, centralized funds management, and strategic sourcing and partnerships with industry to provide optimum logistical support for equipment spares Air Force-wide.[5] The initiatives presented here are examples of the incremental successes being attained throughout the maintenance community every day. That said, perhaps no other area of the maintenance complex has taken process improvement further, or holds more promise for the future, than the ALC's depot maintenance organizations.

It should come as no surprise that the ALC's depot maintenance organizations are accomplishing tremendous things in terms of process improvement. It is within this Air Force community that the idea began. In 1999, well before AFSO21 came into the lexicon of Airmen, the Warner Robins ALC piloted the first continuous process improvement project utilizing an adapted form of the Toyota Production System known as Lean.[6] Very few could have imagined the gains that would continue to be made over the next decade—and it all started with that limited effort in the F-15 wing shop. At Warner Robins ALC alone, aircraft depot maintenance due date performance improved from 83 percent to 96 percent while simultaneously reducing schedule changes by 85 percent.[7] These gains have had a direct effect on aircraft availability by reducing the number of depot possessed aircraft. C-5 aircraft have dropped from 15 in 2003 to 7 in 2007, and F-15 aircraft from 44 to 28 over the same period, giving 8 and 16 aircraft back to the warfighter respectively.[8] The extent of the success at Warner Robins is further evidenced by it being the first-ever public industry to win the Shingo Prize for Excellence in Manufacturing—a feat it has accomplished three more times.[9] Given the incredible accomplishments Warner Robins has had in its approach to improving its maintenance practices, it is no surprise that another ground breaking initiative is coming from this ALC that aims to revolutionize aircraft depot maintenance and provide yet another opportunity to improve aircraft availability to the warfighter. This new concept is high-velocity maintenance.

High-Velocity Maintenance (HVM)

Perhaps no other term has invaded the vernacular and imagination of today's maintenance community more than *high velocity*. The very idea of accelerating processes and pushing aircraft through maintenance activities is at the very heart of many of the key initiatives that are in work today. As it relates to depot activities, HVM is much more than accomplishing inspection and repair requirements more quickly. It is a fundamental change in the Air Force's approach to programmed depot maintenance (PDM).

Much like the adaptation of the Toyota Production System, HVM owes its beginnings to industry practices resident in the commercial market and the compelling need for process improvement. A group of subject matter experts at Warner Robins formed a high-performance team that was chartered to investigate current state PDM processes and industry best practices and develop an implementable HVM concept.[10] Their work laid the foundation for a spiral development effort that culminates in a process that will enable continuous monitoring of aircraft condition—a mechanic-centric focus; a single Air Force-wide maintenance cycle; point-of use-parts, tools, data and equipment; standard work and processes; and information-enabled planning and execution.[11]

The initial review of the current state of PDM operations identified several aspects of the process that inhibited effective completion. First, aircraft are received into the process with limited understanding of the platform's overall condition. This gap between field and depot maintenance activities creates a situation where unanticipated damage and repair actions drive perturbations into the overall schedule.[12] Second, the long-established depot maintenance interval, based on original manufacturer's recommendations, drives a *must fix now* mentality that increases maintenance activities during the depot process. In a system where aircraft do not return to the depot for approximately 60 months on average, a strong emphasis is placed on fixing all discrepancies, even those with slight potential risk for failure, prior to returning to the end user.[13] This has the unintended effect of *gold plating* aircraft depot maintenance activities. Third, there are inherent inefficiencies within the depot work environment itself. Examples that directly impact schedule execution include technicians completing nonvalue added work, such as gathering tools, equipment, and supplies and the lack of kits designed to support maintenance operations that are accurate and complete.[14]

In seeking out potential solutions to overcoming these issues, the team visited a number of commercial sites including American Airlines, Cascade Aerospace, and TIMCO. Three common aspects stood out across all of the companies visited. First, touch labor rates of up to four to five times that of the ALCs were standard business and expected.[15] The high touch labor rates fostered an environment where technicians were focused directly on repair activities and nonvalue added work was diminished. Second, maintenance intervals were significantly shorter for commercial repair organizations.[16] The increase in visits that aircraft made through the repair cycles provided closer monitoring of aircraft conditions and fostered better forecasting for repair and materiel requirements. Lastly, heavy emphasis was placed on detailed, reiterative work planning. Most importantly, such planning incorporates lessons learned from both aircraft repair and task completion in the previous cycle.[17] The combination of increased maintenance intervals (fosters better forecasting) with the detailed work planning proved to be a powerful means for achieving the high labor rates desired (see Figure 1).[18]

The information gathered provided the background necessary to work towards the HVM goals. The team began a pilot program to validate HVM concepts utilizing Air Force Special Operations Command C-130s. The initial work focuses on dissecting the current PDM package into four smaller packages that can be accomplished in shorter intervals, approximately every 18 months.[19] This strategy strives to improve insight into materiel requirements by accomplishing evaluations for the next maintenance cycle at the completion of the current one. This enables the production support planning required to create an integrated, mechanic-centric plan that strives to apply the right resources, at the right time and place, to achieve the desired high touch labor rates throughout the aircraft depot maintenance process.[20] Additionally, the plan goes further by integrating field-level isochronal (ISO) and phased inspection (HSC) requirements into

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occurrences much more acute. Given the rigidity resident in the HVM process, the capacity to address such events may reside within the depot's supporting backshops. This transfer of flexibility is not without constraints, however, as the backshop's competing priorities and materiel availability must be acknowledged and mitigation strategies developed that best support execution of HVM operations. Given the size of the organic depot enterprise and the limited scope of HVM, such strategies are further constrained in that they should be enacted in a manner that does not negatively affect traditional aircraft depot maintenance operations. The ability of depot backshops to reach a balance between traditional and HVM PDM constructs—and to deliver the responsiveness HVM requires—may be the biggest challenge to realizing the anticipated benefits of this shift in depot-level maintenance.

The future of HVM shows great promise. As operational demands remain high, this tool may provide another avenue for squeezing even more out of the Air Force's high-demand, low-density fleets within today's fiscally constrained environment. It is yet another example of the kind of ideas that our innovative and outstanding Airmen, civilian and military alike, develop every day to tackle the difficult challenges we face.

Article Acronyms

AFMC – Air Force Materiel Command
ALC – Air Logistics Center
eLog21 – Expeditionary Logistics for the 21st Century
EPP – EXPRESS Prioritization Processor
EXPRESS – Execution and Prioritization of Repair Support System
HSC – Home Station Check
HVM – High-Velocity Maintenance
ISO – Isochronal
PARS – Prioritization of Aircraft Repairables
PDM – Programmed Depot Maintenance
SPRS – Spares Priority Release Sequence
UMMIPS – Uniform Military Movement Issue and Priority system

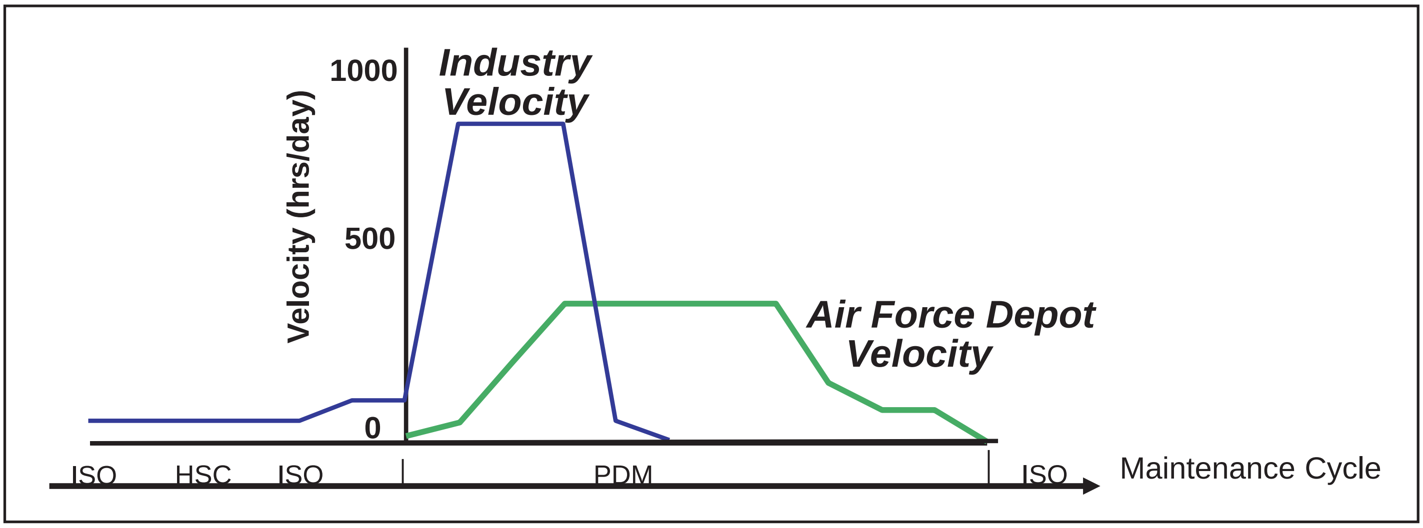

Figure 1. Notional Touch Labor Rate Comparison

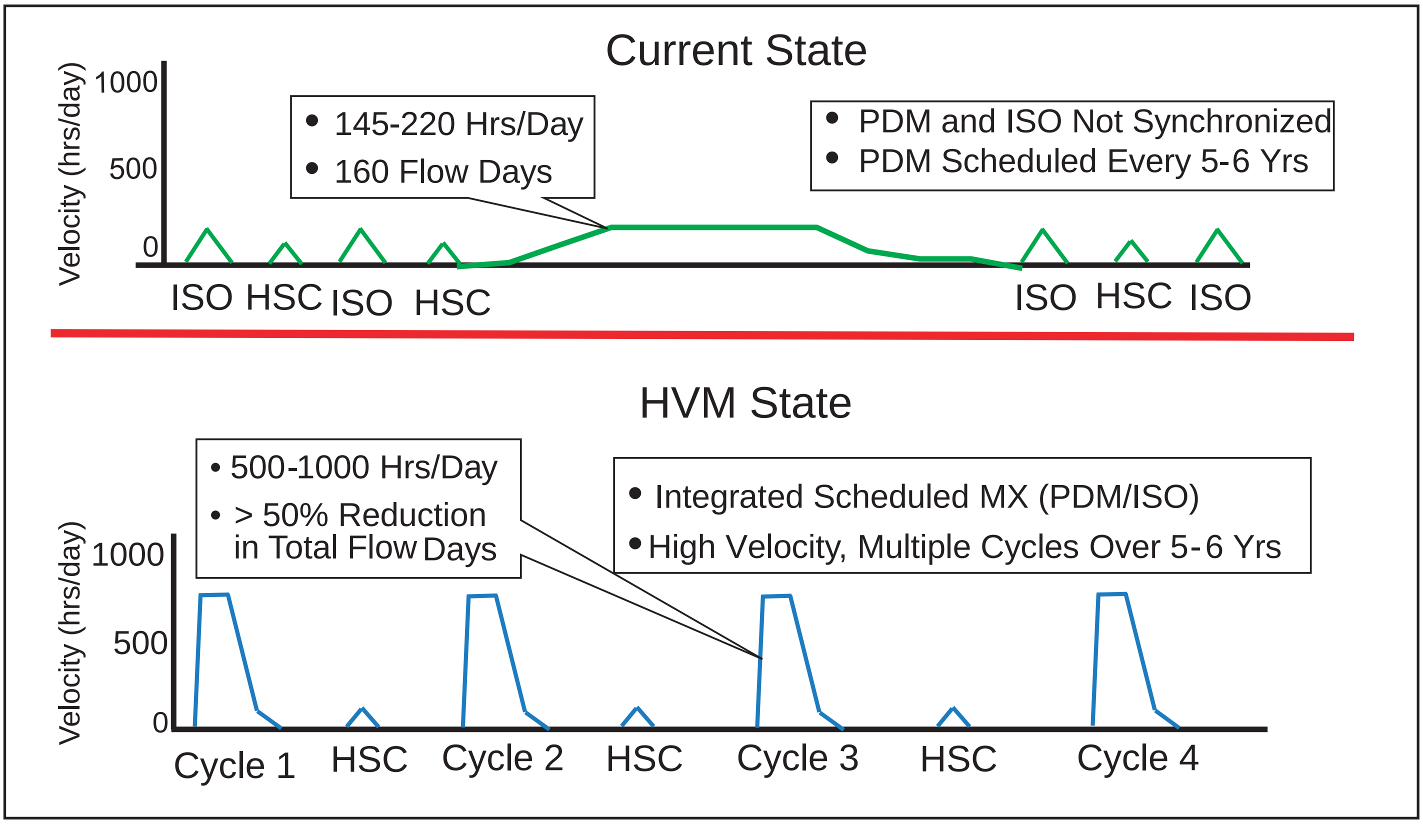

Figure 2. Current and Future State Depot Maintenance Cycles

the depot process. Accomplishing this will reduce scheduled aircraft maintenance downtime in the operational environment.[21] Last, it addresses two systemic issues inherent in the current depot process: unanticipated maintenance requirements and the compelling need to conduct unnecessary repairs based on long periods between PDM cycles. A notional chart of current and future state depot processes is illustrated in Figure 2.[22]

The impact of forecasting requirements and aligning materiel support for long lead-time items cannot be overstated. In order to achieve the pace desired, the detailed maintenance plan will need to be finely orchestrated in such a manner as to place manpower, materiel, and requirements at finite points along the process in order to facilitate the high touch labor rates desired. This approach to PDM necessitates a level of rigidity in execution that will not be capable of tolerating a large amount of unanticipated and unscheduled repair requirements. Although such events should be limited due to increased visibility of aircraft conditions evaluated during the prior PDM, it is unreasonable to expect that such conditions will not exist at all. One area that will be key to sustaining the time-critical flow of HVM depot operations will be the depot backshops. Understanding the process with which depot backshops prioritize and schedule requirements will determine how effectively they can integrate HVM demands into existing processes.

Depot Backshop Support

ALC depot backshops are vital resources that have an impact well beyond traditional depot maintenance operations. The unique repair capabilities that reside in the capital equipment and an experienced workforce are in high demand throughout the Air Force repair enterprise. In contrast to commercial aircraft maintenance and repair organizations, depot backshops are not solely dedicated to a particular weapons system, product line, or ALC in which they reside. This distinction highlights the complexity of managing a diverse workload originating from several different sources and meeting the demands in a manner that satisfies customer needs without adversely impacting other customers. HVM operations will not only be another customer competing for these limited services, but one that will require them at an accelerated pace. The responsiveness required to ensure zero lag in the HVM process requires its inputs to be considered at a higher priority than its traditional counterparts. Understanding the system that the backshops use to schedule workload, its prioritization logic, and methods for addressing shortfalls and limitations within the existing framework is critical to determining the impact HVM and backshops will have on one another. This understanding will be key in developing adaptable and effective mitigation strategies for future use.

Aligning Depot Backshop Workload

The primary tool utilized to make backshop repair decisions is the Execution and Prioritization of Repair Support System (EXPRESS). EXPRESS merged and integrated several initiatives for identifying and prioritizing depot repair requirements based on weapon system operating requirements and readiness targets with the aim of aiding maintenance managers in decisionmaking in a resource-constrained environment.[23] On a daily basis, the system compares operational and organic depot repair requirements to global inventory levels and depot repair capacity.[24] By combining this information the automated system produces time-horizon based repair priorities for Air Force Materiel Command (AFMC) managed items based on the depot's ability to support the repair actions. The EXPRESS system is comprised of three functional modules that work together in deriving workload requirements.

- Prioritization of Aircraft Repairables (PARS)
- EXPRESS Prioritization Processor
- The Supportability Module

The PARS system is the first stop in establishing daily workload requirements for each backshop. The module takes into account base flying activity, asset position, and aircraft availability goals, then attempts to fill system demands by the most expedient means available.[25] Once requirement data has been gathered, the system will utilize one of two methods for forecasting demand in order to establish priorities. The first method—the preparation process—bases future demands on operational flying activity. The second method—the computation process—is based on existing stock levels.[26] The outcome of this process is a prioritized list of Air Force-centric required repair actions that are best aligned to meet overall weapon system availability goals. This completed list will then feed into the second module of EXPRESS.

The second module, EXPRESS Prioritization Processor (EPP), applies a daily single prioritization across weapon systems algorithms to PARS. EPP ensures an even distribution of support across weapon systems and produces a rank ordered list of repair requirements. EPP then adds non-PAR repair demands to this product, such as foreign military sales and other Service requisitions, and integrates these requirements within the prioritized list based on priority code and document date.[27] Once all demands have been established, EPP produces a single integrated list of all repair priorities for each repair shop. The process flow from PARS through EPP is depicted in Figure 3. It is this integrated list that provides the source document for the Supportability Module.

EXPRESS accomplishes an initial feasibility check of all repair requirements through its Supportability Module. The module provides an automated validation of repair viability based on four criteria. Each requirement is checked for the availability of a repairable carcass, parts required to support the repair, funds availability, and backshop capacity.[28] Requirements that fail any of these four criteria are identified at the shop level, where workload managers have the opportunity to resolve constraints. There are certain limitations that impact the module's effectiveness, especially as it relates to support of HVM PDM operations. Inaccuracies in bench stock inventories and bills of materiel drive inaccuracies into the supportability logic and indirect parts and materiel are automatically excluded.[29] These issues may cause items to appear supportable even when materiel support is not available. One positive aspect to depot operations, however, is that carcass and funding constraints will not be significant challenges with the aircraft being on site and funding centrally managed by AFMC.

Prioritization Methodology

EXPRESS uses the combination of PARS and EPP to produce an integrated list of repair requirements. The first step in prioritizing this list is applying the spares priority release sequence (SPRS)

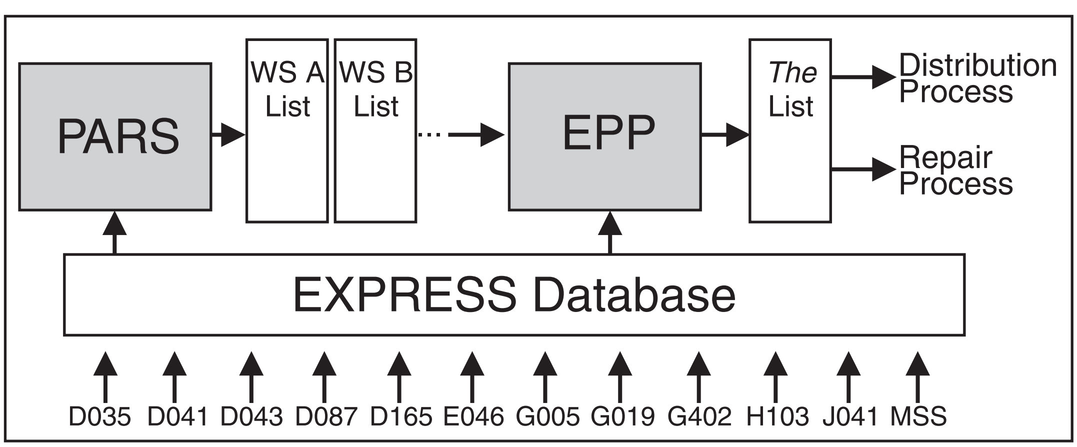

Figure 3. Prioritization of EXPRESS Flow

rules to the requirements. SPRS rules were developed and approved by major command commanders during the June 1999 Corona and implemented the following February.[30] The rules define Air Force needs based on importance and assign SPRS sequence numbers that give precedence to those units located at the forefront of operational needs. Table 1 provides an overview of the release sequence where repair requirements are staged by priority, then by needs within these groupings, giving preference to JCS mission capability requirements.[31] Given its operational focus, depot requirements are not considered during this phase of the prioritization scheme and may even be delayed due to pressing SPRS requirements.

Once SPRS priorities have been accomplished, the remaining requirements are prioritized using optimization logic. Optimization uses four key inputs in determining order: serviceable stock, allowable holes, wholesale resupply lead time, and depot man-hours needed to complete repair.[32] The first look is at serviceable stock at a particular location or stock that may soon be available for use. Second, shortages are reviewed and prioritized based on impact to aircraft availability goals. If a material shortage does not prevent meeting availability goals, then it is placed behind requirements where such an impact exists. Third, the lead time required to keep forecasted requirements ahead of flying-hour programs, historical failure rates, and historical daily demand rates for assets is considered and the requirements placed into the prioritization (at a point to preclude negatively impacting an organization). Lastly, depot man-hours available to accomplish repair activities are considered a limited resource, and therefore, as a cost variable. They are factored in with the intent on maximizing customer support within the available man-hours. Known aircraft depot maintenance requirements will be considered during this process.

EPP completes the prioritization process. The combined SPRS and optimization logic provided the majority of requirements for repair. However, since PARS data only considers Air Force requirements, those assets required to fill foreign military sales or other Service requirements (Army, Navy) need to be included. EPP does this by applying a placeholder logic for items relative to Air Force requirements based upon the uniform military movement issue and priority system (UMMIPS). For example, if a foreign military sale item is number three on a UMMIPS list of ten like items in demand worldwide, it will be integrated on the EXPRESS listing in the same position during the EPP process. The same approach is used for other Service back orders. Depending on where these demands are inserted, depot maintenance requirements may be delayed due to pressing operational needs or contractual obligations.

SPRS #	Priority	Requirement
08	1	JCS MICAP
07	1	Non-JCS MICAP
06	1	All Others
05	2-15	JCS MICAP
04	2-15	Project Code 700 MICAP
03	2-15	JCS Kit Requirement
02	2-15	Project Code 700 Non-MICAP
01	2-15	Non-JCS MICAP

Table 1. SPRS Release Sequence

Programmed Depot Maintenance Inputs

Traditionally, PDM requirements have remained a low priority when compared to operational needs. The long duration of the aircraft depot maintenance process has enabled it more flexibility in overcoming delays resulting from constraints in the backshop repair process. Workload managers have had the ability to adjust within the traditional depot schedule to accommodate delays or utilize newly induced aircraft with serviceable assets (as a source for cannibalization) to address the lag in the job-routed repair time line. These characteristics of the current PDM environment require rethinking when applied to HVM operations. HVM does not have the luxury of either of these approaches. The responsiveness of backshops in the HVM construct becomes much more significant as a result.

Fortunately, few areas in the backshop environment work job-routed and EXPRESS items concurrently. For those sections that must accommodate such workloads, demands are handled manually by workload managers. The most pressing constraint that a job-routed repair will incur is raw material and consumable supply supportability. Where supportable and operational demands permit, aircraft job-routed items are inserted immediately into the repair process. Although the repair requirements of job-routed items are typically lighter, their inclusion into the backshop's scheduled workload decreases overall efficiency and exaggerates preexisting technician and equipment resource constraints. The optimum solution employed currently is to divide workload and assign a separate team, when available, to accomplish the additional workload independently.

Intervention Framework

There are opportunities to physically intervene and manually alter the prioritization list originating from EXPRESS. However, these options are limited and directly related to specific constraints. They do not specifically increase the velocity of the backshop repair cycle. Workload managers can intervene for any of the following five reasons: interchangeable and substitution issues, erroneous parts data, validated data discrepancies, and equipment and personnel constraints.[33]

The first three intervention causes are data related. For interchangeable and substitution issues, a new stock number may be added but only if there is an offsetting deletion of the stock number that it replaces. Erroneous parts data may be addressed by either enabling repair actions when parts research discovers supportability that EXPRESS did not or by removing an item from repair when parts are not on hand. The final data-driven cause for intervention occurs when data discrepancies are found and validated. In these instances, workload managers determine what the repair requirement and priority should have been and make appropriate adjustments to the prioritized list. Overall, adjustments related to data discrepancies should have minimal impact to HVM operations.

The remaining two causes for intervention are based on shop capacity. EXPRESS bases shop capacity on hours available and does not consider the type and quantity of equipment or workforce skills. Workload managers accomplish a daily review of EXPRESS repair requirements to ensure capacity has not been exceeded. This review adds shop expertise to the supportability module and provides opportunities for workload managers to optimize repair activity within shops. Adjustments concerning equipment and personnel have the most potential for affecting backshop support but remain limited in overall impact.

Analysis and Recommendations

The relationship between HVM PDM and supporting backshop operations in the long term will improve. As HVM matures within a weapon system, the forecasting of requirements will be enhanced. Such visibility decreases the scheduling risk associated with repair turn time and will enable workload managers to induce requirements in anticipation of the need date required of the HVM process. The improvement of integrating requirements in a scheduled (vice sporadic) manner will serve to improve efficiency, minimize capacity constraints, and optimize workload mix within backshop sections. However, getting to this point requires consideration in the near term of HVM process implementation, prioritization of HVM requirements, materiel availability, and backshop resource mix.

HVM Process Implementation

HVM is in its initial stages of development and implementation, and faces challenges with regard to backshop capability. A vast majority of these hurdles will be caused by inadequate visibility into aircraft condition prior to PDM induction. Over the near term, HVM designers will need to account for potential delays related to unforeseen repair requirements needing backshop support. Managers have the ability to mitigate such risk through initial one-time inspections or anticipation.

As a weapon system initially transitions into an HVM construct, the first pass an aircraft makes through its PDM interval will pose the most risk of unforeseen repairs. Where feasible, initial inspections should be accomplished in order to target potential damage areas associated with the particular phase of HVM. A list of high-failure items based on historical data can be developed and provided to the units. This list can be accomplished as part of depot maintenance preparations being done at the operational unit prior to the aircraft's first inspection under HVM conditions. Another alternative where operational demands make blue-suit inspections untenable is to have these one-time inspections performed by depot personnel. Such inspections would benefit from the specialized skills and experience residing in depot maintenance personnel. Subsequent inspections for the following depot intervals will be accomplished as part of the HVM process itself. Despite the limited scope these inspections would entail, they would provide valuable additional lead time if backshop repairs are required.

The second strategy is to anticipate where backshop-related repair requirements may reside within the HVM process flow. By pre-identifying these points in the process, various courses of action may be developed ahead of time that can lessen the overall impact of an unscheduled repair requirement. Mapping out the components where there is a high probability of failure and the subsequent points in the process where to reintroduce a repaired item provides workload managers more fidelity in matching backshop turn time to schedule. It also gives backshop workload managers more insight into where best to fit depot needs into the overall requirements demand mix. For both organizations, such anticipation provides some measure of flexibility within the rigid HVM framework and limits the impact to workforce efficiency that results from common schedule perturbations.

HVM Workload Prioritization

In time, HVM will dovetail well into the current priority framework that backshops use to align workload. As aircraft condition becomes more certain and the experience gained in accomplishing targeted inspections for each HVM segment grows, requirements for backshop related repairs will be identified well ahead of the necessary lead time. Additionally, the shorter timespan between HVM segments improves the ability of engineers to contrast component life span in a more determinant fashion that may reduce overall repair requirements over time.

In the interim, HVM requirements needing backshop support may actually increase. With more focused inspections in targeted areas, new trends may arise and drive more diverse groups of items into the repair cycle. Strong consideration should be given to ensuring these items are put into work in a manner that precludes any work stoppage in the HVM process. In light of the improvements in aircraft availability that are anticipated by transitioning to HVM, such time-dependent requirements provide a strong case for being placed on par with the operational demands considered in the spares priority release sequence rules. The impact of this shift in priorities to operational customers would most likely be negligible given the limited number of weapon systems currently being considered for HVM. Further, such delayed, time-dependent demands should decline as HVM matures within the weapon system and requirements transition into the existing optimization category of the prioritization process. The ability to mitigate this issue will be a critical factor in determining the successful implementation of HVM depot operations.

Materiel Availability

A key portion of the HVM process design is the development of kits that are aligned to each HVM package. Kitting serves to reduce man-hours and increase efficiency across the depot maintenance process by ensuring the appropriate mix and amount of consumable materiel is available prior to beginning maintenance. Materiel availability can also be a limiting factor in the backshop's ability to accomplish repairs in a timely manner. Two constraints need to be addressed for effective support: carcasses and raw material.

With aircraft in depot maintenance, carcasses should not be a substantial issue unless condemnation rates are significantly high. In such instances, item managers should be consulted and options for increasing serviceable inventories developed. For systemic issues, engineering support may be leveraged to improve component design for reliability and maintainability. The more prevalent but preventable issue is the raw material inventory needed to accomplish repairs. The compressed repair cycle cannot afford delays related to lapses in materiel availability. Where appropriate, it is recommended that additional inventory investments be made that are targeted to HVM-related requirements. Management of such stocks should be done to not only preclude material shortages but also to prevent inventory growth beyond a defined time-determinant level. As HVM matures and repair data indicates, such specialized inventories should be reduced when no longer necessary or the risk has subsided to a manageable level.

Backshop Resource Mix

The backshops will remain constrained in both skilled technicians and high-demand capital equipment. Equipment constraints are relatively known and backshop managers have existing methods for aligning workloads to match up with equipment availability or for accomplishing work by other means. Additionally, it is likely that most job-routed repair requirements resulting from HVM operations will be smaller in scope as compared to overhaul work. It is likely that job-routed repair work will remain mostly accomplished by technicians using standard tools and processes that are not equipment dependent. Therefore, equipment constraints will not be influential in HVM success, but skilled technicians will be.

It can be argued that there are never enough skilled technicians to accommodate the heavy demands placed on depot backshops. Adding the pressure of time-dependent HVM requirements only exasperates the condition by placing more technician-centric demands on the organization. The backshop workforce has shown great flexibility in meeting the increasing demand for some time. Managers may elect to add multiple shifts to an already busy schedule or attempt to address the shortfalls through increased overtime. Neither of these provides a permanent or sustainable solution to the problem. As HVM looks to employ more personnel to achieve the high touch labor rates necessary to meet their time line, a relative percentage of that total increase based on workload should be considered for backshop operations. Additionally, a more versatile workforce that provides managers the flexibility to shift technicians to spikes in workload should be investigated within the guidelines agreed upon with union leadership. Such flexibility between backshop and line operations has the potential to improve overall skill level and working relations throughout the depot repair enterprise. Addressing this aspect of backshop support is important to the overall success of HVM implementation.

Conclusion

In the end, it is all about improving warfighter capability. Maintenance's role in this endeavor is to increase aircraft availability by reducing maintenance related downtime. The community has diligently been working in that direction for over a decade through a myriad of continuous process improvement initiatives. High-velocity maintenance is only the latest iteration along this path but one that holds great promise, especially when applied to the Air Force's high-demand, low-density fleets. But the concept cannot go it alone and will require the depot backshop environment to produce some measure of flexibility to optimize the process rigor that is built into the HVM construct.

As the embodiment of the next evolution in continuous process improvement, HVM represents the transition from doing Lean to being Lean. In its initial development, the Air Force Special Operations C-130s will be the test case. If successful, the migration to the larger C-130 fleet should improve availability by 14 percent.[34] The tangible result is 55 more aircraft at a cost of $1.6B accomplishing missions (not sitting). To the operational maintainer, HVM serves to reduce costs, facility constraints, and workload through the inclusion of ISO inspections into the accelerated time line. For the depot itself, it provides greater insight into aircraft condition, which improves requirements forecasting, and has the potential for reducing scheduling perturbations and the resultant delays. The more mature weapon systems become within the framework of HVM, the more pronounced the benefits will be.

The depot related benefits extend to the supporting backshops, but they will not necessarily be realized until the initial migration of a weapon system into the concept has been completed. In the interim, they will be leveraged in place of the flexibility that is wrung out of the HVM process. The prioritization of HVM demands, backshop material availability, and resource constraints are issues that need to be addressed by workload managers to mitigate scheduling risks that may hinder successful HVM operations. Despite the limited exposure to such risk, their occurrence could hamper HVM operations. Fortunately, the depot backshops have the foundation and capability to overcome these hurdles. In review of their current practices, they appear to pose only a moderate risk to the successful implementation of HVM.

Although the risk attributed to depot backshop operations is moderate, it does not lessen the negative perceptions that will be applied to the overall HVM concept when lapses do occur. There will be errors in planning, unforeseen maintenance requirements, and mistakes made across the logistics enterprise in supporting and executing depot operations under the HVM construct. These glitches will predominate the earlier transition phases and lessen over time, but will never completely abate. Therefore, managing the expectations of Air Force leadership, as well as command customers, must be at the forefront of those enterprises championing high-velocity maintenance. Not doing so may result in the snowballing of negative sentiment that has the potential of strangling the infant HVM concept while still in its crib. This truth not only applies to backshop support, but to all facets of HVM.

The future of HVM shows great promise. As operational demands remain high, this tool may provide another avenue for squeezing even more out of the Air Force's high-demand, low-density fleets within today's fiscally constrained environment. Lastly, it is yet another example of the kind of idea that our innovative and outstanding Airmen, civilian and military alike, develop every day to tackle the difficult challenges we face. HVM is today's solution. Tomorrow's most likely will be even greater.

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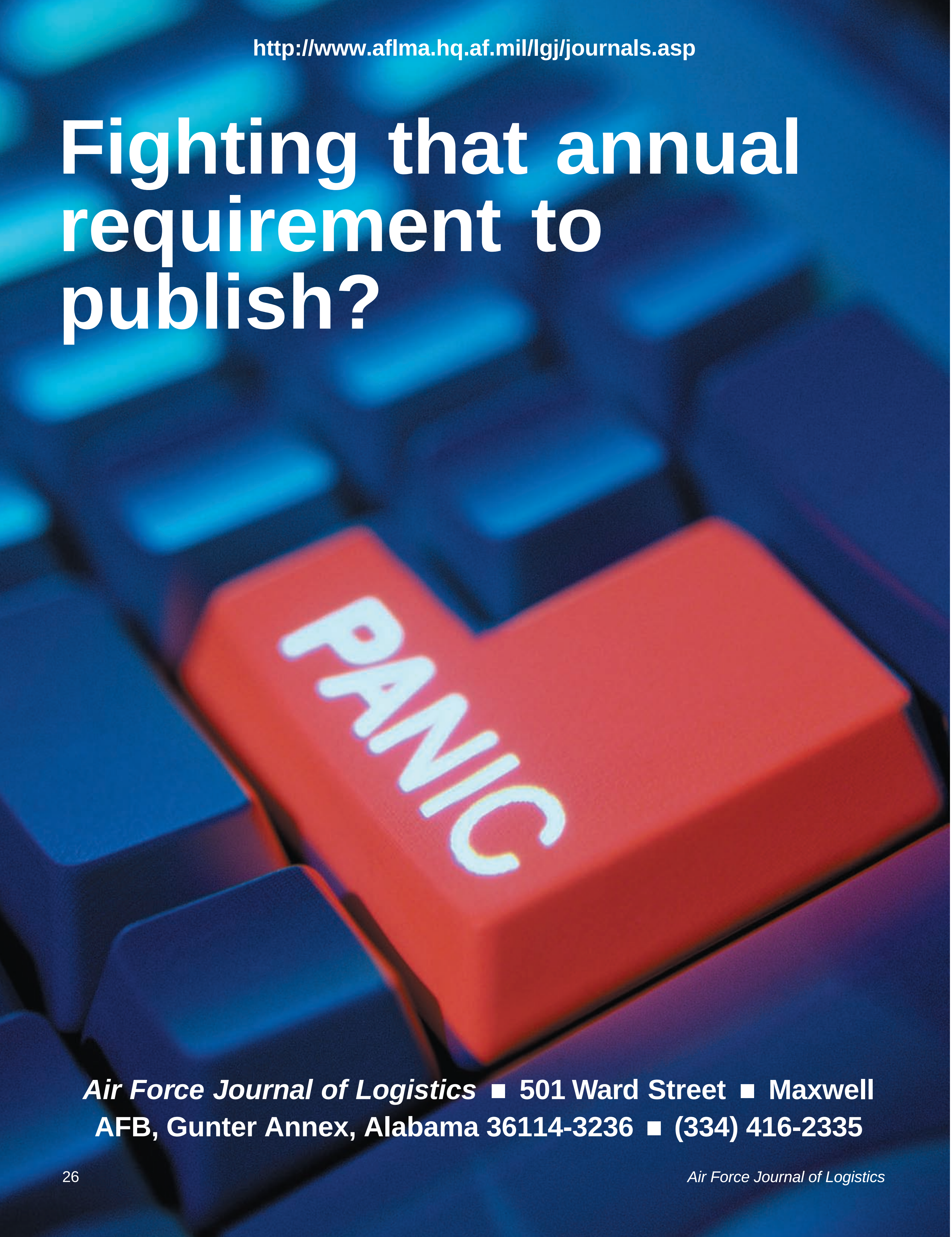

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There are no simple solutions to the economic challenges facing our country and the affordability issues surrounding the Air Force's modernization and recapitalization requirements. In the final analysis, affordability (like beauty) is in the eye of the beholder.

contemporary issues

Can America Afford to Modernize the Air Force?

In "Can America Afford to Modernize the Air Force?" Colonel George A. Coggins looks at why the Air Force needs to modernize its air and space fleets, explores domestic considerations likely to influence these efforts, and provides a historical perspective on military spending trends and different approaches for determining defense funding levels. He concludes with an assessment of affordability concerns and recommendations. Leaders with a firm understanding of these issues will be better prepared to assess and articulate the potential impacts of funding decisions on national defense. This, in turn, should better posture the Air Force to maximize its contributions to national security as we fight today's wars, while preparing for the future.

The major recommendations presented in this article are as follows.

- **Reassess America's national security policy and the role of the military (and other instruments of national power) in the new security environment.** America's military can do just about anything, but it cannot do everything. Our leaders must apply the first rule of management—balancing commitments with resources. This will require a realistic assessment of the threat environment and global commitments, clearly defining the roles and mission of each instrument of national power, and adequately resourcing these functions. To better synchronize priorities with resources, the US should establish a unified security budget for key players involved in providing national security. This would include the Departments of Defense, State, and Homeland Defense, along with others as deemed appropriate. The Department of Defense may lose some budget authority as part of this rebalancing process; however, since US national security is based on the skillful application of both hard and soft power, this may be the most efficient and effective use of limited funds.
- **Restore fiscal balance through prudent spending cuts and more effective tax policies.** A strong economy is a prerequisite for a strong military. Unfortunately, the US is on an "unsustainable fiscal path" that will ultimately impact our national security. No politician in his or her right mind wants to propose cutting entitlements or raising taxes, yet this is precisely what must be done to rein in America's out of control budget—and the sooner the better. The longer we wait to address deficit spending and the tsunami wave of Social Security and Medicare bills bearing down on our country, the more drastic future cuts will have to be. Politicians should consider increasing the minimum age for drawing Social Security, repealing the Medicare drug care program, and re-evaluating tax policies (to include reversing prior tax cuts or abolishing the IRS and substituting a national sales tax for personal income taxes).
- **Pursue a long-term strategy for revitalizing the US defense industrial base.** The government should identify those critical skills, technologies, and manufacturing capabilities that are needed to ensure the long-term viability and technological superiority of the US defense industrial base. This will require a sustained effort spanning decades and considerable investment, but the potential benefits are substantial. First, it encourages the development of more scientists and engineers which increases America's intellectual capital. Second, domestic production creates more jobs which contribute to the nation's overall wealth. Finally, and most importantly, it provides an opportunity for America to regain its position as a leading manufacturer among world producers.

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Can America Afford to Modernize the Air Force?

George A. Coggins, Colonel, USAF

Introduction

Rising to the 21st century challenge is not a choice. It is our responsibility to bequeath a dominant Air Force to America's joint team that will follow us in service to the nation.[1]

—General T. Michael Moseley, Former Chief of Staff of the Air Force

America's edge, according to the 2008 *Air Force Posture Statement*, is based on the synergistic effects of global vigilance, global reach, and global power—our nation's ability to gain and maintain situational awareness, fuse intelligence from multiple sources, and rapidly respond with swift and precise effects to any point on or above the earth.[2] These capabilities allow the United States (US) Air Force to hold any target in the world at risk, defend our homeland, or deliver humanitarian aid to those in need.

However, the Air Force is at a strategic crossroads. Strained by 17 years of continuous combat operations throughout Southwest Asia, its fleet of air and space vehicles as well as supporting infrastructure are rapidly wearing out or becoming technologically obsolete. Reversing this trend and revitalizing these capabilities will not come cheap. By one account, the Air Force needs at least an additional $20B annually to pay for critical modernization requirements including tankers, fighter aircraft, long-range strike assets, and space platforms.[3]

This phenomenon is not limited to the Air Force. The Army, Navy, and Marines are experiencing similar modernization and recapitalization challenges resulting from the high operating tempo demanded by ongoing operations in Iraq, Afghanistan, and other contingencies around the world. The sheer volume of flying hours, steaming hours, and track and wheel miles in a combat environment is accelerating the wear and tear on most military hardware and burning up the expected service lives of critical assets. Unless these systems are repaired and replaced in sufficient numbers, the United States risks losing its battlefield dominance and command of the global commons—air, sea, space, and cyberspace—as the threat environment becomes increasingly dangerous and America's relative military advantage shrinks.

One could argue the simple solution is to increase defense spending so the Services can repair and modernize their forces. Unfortunately, the United States is on a fiscally unsustainable path resulting from unchecked growth in mandatory programs such as Social Security, Medicare, and the interest on our national debt.[4] This looming fiscal crisis, coupled with a shrinking US defense industrial base, will make it difficult, if not impossible, for America to modernize the Air Force.

This article examines why the Air Force needs to modernize its air and space fleets, explores domestic

considerations likely to influence these efforts, and provides a historical perspective on military spending trends and different approaches for determining defense funding levels. It concludes with an assessment of affordability concerns and recommendations. Leaders with a firm understanding of these issues will be better prepared to assess and articulate the potential impacts of funding decisions on national defense. This, in turn, should better posture the Air Force to maximize its contributions to national security as we fight today's wars, while preparing for the future.

The Case for Modernizing the United States Air Force

Airpower is like poker. A second-best hand is like none at all—it will cost you dough and win you nothing.

—General George Kenney, First Commander of Strategic Air Command

Today's Air Force is arguably the most dominant air and space force in the history of the world. American aircraft patrol the skies over Iraq and Afghanistan, unchallenged by enemy air forces, while ground forces conduct missions without fear of attack from above. This confidence is well-founded—no US soldier has been killed by an enemy aircraft since April 1953, nearly 56 years ago.[5]

The Air Force's brand of air dominance—total, unquestionable, and suffocating—has been around so long, according to Rebecca Grant, director of the Mitchell Institute for Air Power Studies, that many now view it as a birthright.[6] Considering almost two decades have passed since American warplanes drove Saddam Hussein's air forces from the skies during Operation Desert Storm, it is easy to see how some people can come to this conclusion. However, this flawed view overlooks the risks posed by an increasingly dangerous threat environment and the effects of an aging air and space fleet.

It's a Dangerous World Out There

Pick up any newspaper or peruse your favorite news Web site and you will see constant reminders of the dangerous world we live in. Recent headlines include coverage on the terror attacks in downtown Mumbai, pirates hijacking vessels in the Indian Ocean, Iran's recent ballistic missile tests, and Russia's invasion of Georgia. In light of these events, the United States Air Force must be capable of dealing with a number of daunting challenges—fighting terrorism, dealing with the emergence and reemergence of peer competitors, and countering adversaries armed with more advanced, lethal weapon systems.

On 11 September 2001, terrorists launched the most deadly attack in American history. These brazen strikes on American soil ushered in a new era for our nation—the Long War on Terror. Seven years and $700B later, American forces steadfastly defend our homeland and relentlessly hunt down terrorists throughout the world. Terror groups, such as Al Qaeda and Hezbollah, still pose a growing threat to the international community. As a result, the United States and other countries in the world must be equally committed and capable of preventing such attacks.

At the end of the Cold War in the mid-1980s, the United States stood as the sole superpower in the world. No other country could rival its combined military and economic might which led to a decade-long *procurement holiday* for the US military. Yet, as America reduced its military force structure and deferred or cancelled modernization programs, other nations reconstituted and expanded their military capabilities. According to the 2006 *Quadrennial Defense Review* report, the future international security environment will most likely be shaped by an emerging China, resurging Russia, and expanding India.[7]

China is seen as having the greatest potential to compete militarily with the United States and could, over time, field military technologies capable of offsetting traditional US military advantages. This should come as no surprise as China converts its growing economic might into military capabilities. For example, within the last several years, China announced the fielding of one of its most advanced fighters, the J-10, and successfully tested an anti-satellite weapon against an orbiting spacecraft.[8] Although China's intentions remain veiled, one analyst posits China will have the military capacity to pose a national survival threat to America in less than a generation.[9]

The proliferation of advanced weaponry also presents a growing threat to American air and ground forces. Today, one is just as likely to find Russian SA-20 and Tor-1 systems in Iran as American-made Stingers in the hands of Iraqi insurgents. As potential adversaries acquire relatively inexpensive, yet capable, man-portable air defense systems, double digit surface-to-air missile systems, and fourth generation fighters, they may well be able to array more formidable air defenses thus potentially denying US access to their airspace.

Soviet and Chinese aircraft, notably the MiG-29, MiG-31, and Su-30, also pose a growing threat to American forces and rank among the top-selling fighters in the world. These jets, while not as advanced as the new F-22 or F-35, are capable of engaging and defeating America's legacy air superiority fighter, the F-15C. In 2005, Indian pilots flying Soviet-made Su-30Ks and French-made Mirage 2000s accomplished something unthinkable just a few short years ago—they defeated American pilots in simulated combat engagements as part of a recurring training exercise dubbed Cope India.[10]

While the debate rages on whether it was a *square fight* between the US and Indian forces, the implications are obvious. America's monopoly on technological superiority and relative

Article Acronyms

CLS – Contractor Logistics Support
CRS – Congressional Research Service
DoD – Department of Defense
DPEM – Depot Programmed Equipment Maintenance
FHP – Flying Hour Program
GAO – Government Accountability Office
GDP – Gross Domestic Product
GWOT – Global War on Terror
ISR – Intelligence, Surveillance, and Reconnaissance
PPBES – Planning, Programming, Budgeting, and Execution System
PPBS – Planning, Programming, and Budgeting System
SAM – Surface-to-Air Missile
SSA – Social Security Administration
US – United States
USAFCENT – United States Air Forces Central Command

military advantage is shrinking—and not just in the air domain. Commercial satellite imagery is readily available on the open market, hackers infiltrate and exploit computer networks, and terrorists use the Internet to rapidly share tactical lessons learned, such as instructions for incorporating cell-phone detonators into roadside bombs. These threats—and others such as climate change, resource shortages, and pandemics—clearly indicate our world has, indeed, become an increasingly dangerous place.

Growing Old Ungracefully—An Aging, Worn-out Fleet

Most people view the Air Force as the newest, most technologically advanced military in the world. Flashy images of F-22s, Global Hawks, and Predators dominate the press and certainly reinforce this perception. However, they may be surprised to learn these three advanced systems represent less than 5 percent of Air Force aircraft.[11] The remaining 95 percent of the fleet includes over 400 Eisenhower-era tankers and nearly 200 bombers and cargo aircraft averaging over 45 years old. This highlights one of the most serious challenges to American air and space dominance—an aging, less capable fleet.

The Air Force is currently operating the oldest fleet in its history. On average, the fleet is over 24 years old with many platforms approaching the half-century mark. See Table 1 for the average age of a representative cross-section of Air Force systems.[12]

Planned acquisitions will not reverse this trend anytime soon. According to one official, the Air Force plans to acquire approximately 60 aircraft per year which equates to a 100 year recapitalization rate based on a 5,700-plus aircraft fleet.[13] As a result, the average age is soon expected to exceed 30 years with some systems projected to reach the 75- to 80-year mark.[14]

Seventeen years of continuous combat operations is also accelerating the wear and tear on Air Force systems and burning through the expected service lives of critical assets. Since Desert Storm, the Air Force has flown over 2.3 million hours annually, but with a force that is 31 percent smaller and 42 percent older.[15] According to Lieutenant General Gary North, commander of Ninth Air Force and US Air Forces Central, "We are flying our planes into extinction."[16]

The case for Air Force modernization goes far beyond its aging air and space fleet. Years of reduced funding for new facilities and the cumulative effect of deferred maintenance are also impacting critical infrastructure capabilities including aircraft depots, space launch facilities, base maintenance, and specialized communications facilities. Other less obvious, but essential infrastructure requirements include upgrades to training ranges, runways, material handling equipment, fuel distribution systems, and adequate housing for our Airmen and their families. Just as most people do not want to go to war in a 50-year-old aircraft, they should not be expected to work or live in similarly outdated, inefficient support facilities.

Aging Fleet = More Costly, Less Reliable Systems

In one respect, air and space vehicles are no different than a personal automobile. As they age, they become less reliable and cost more to operate and maintain. Much like a family automobile purchased in 1980, military systems procured during the Cold War are showing their age as evidenced by more frequent incidents involving structural issues such as cracked wings, struts, and corrosion. For example, the Air Force was forced to ground its entire F-15C fleet in 2007 after an aircraft disintegrated while conducting routine air-to-air combat training in the skies over Indiana.[17] As recently as October 2008, dozens of A-10 jets were grounded at Davis-Monthan Air Force Base (AFB), Arizona after inspectors found cracks in the wings. These problems are not isolated to fighter and attack aircraft.[18] Similar safety and structural issues have been discovered in cargo, aerial refueling, and intelligence, surveillance, and reconnaissance platforms. One official noted the Air Force's C-130Es are so broken they can no longer deploy in combat.[19] As of August 2008, over 700 aircraft, or 13 percent of the entire Air Force aircraft fleet was either grounded or operating under flight restrictions.[20]

Finally, it is also increasingly expensive to operate and maintain aging aircraft. As Figure 1 illustrates, the cost of depot programmed equipment maintenance, contractor logistics support, and the flying-hour program increased by 179 percent over the last 10 years even as the Air Force reduced the size of its fleet by over 9 percent.[21] So, as you might expect, keeping over 5,000 aircraft airworthy requires massive investments in terms of manpower and money. The Air Force is expected to "spend a billion dollars per week in fiscal 2010 on fuel, spare parts, repairs and technical support—and that doesn't even include the paychecks for military personnel performing such functions."[22]

Domestic Factors Influencing Air Force Modernization Efforts

To ask whether the United States can afford higher levels of military spending is stupid. It can, and if necessary, it would. The problem is that there are other important things that the United States wants and can afford too, and a dollar spent on one thing cannot be spent on another.[23]

—Richard Betts, US National Security Specialist

There are significant risks on the horizon that may derail the Air Force's modernization and recapitalization efforts. Unchecked growth in domestic programs such as Social Security, Medicare, and Medicaid, coupled with decades of deficit spending and the effects of the credit crisis, threaten our nation's solvency. Even if America's leaders can reverse these trends, there are many concerns about the US defense industry's ability to develop the systems and technologies needed for our national defense. We begin by scanning the budgetary landscape.

System	Number	Average Age	Oldest	Newest
A-10A	208	27.3	Apr 79	Mar 84
F-15C	325	25.2	Jun 79	Oct 89
F-16C	1029	18.5	Oct 84	Mar 05
B-1B	66	21.0	Sep 86	Jul 88
B-52H	89	46.7	Jan 60	Oct 62
KC-135R	363	46.8	Jun 58	Dec 64
C-5A	59	36.9	May 70	May 73
C-130E	98	44.3	Jun 61	Feb 74
C-130H	269	21.1	Aug 74	Mar 94
HH-60G	101	18.2	Dec 82	Feb 99
Minuteman II	570	34.0	Apr 70	Dec 78
GPS satellites	31	9.0	Nov 90	Mar 08

Table 1. Inventory and Average Age of Air and Space Systems

The Looming Fiscal Crisis

The United States faces a looming fiscal crisis; however, most Americans and virtually all politicians turn a blind eye to this inconvenient truth. According to David Walker, the Comptroller General of the United States of America, "Today, we're seeing the calm before the storm from a fiscal standpoint…but, we face a tsunami of spending that will reach our shores within the next several years, and we are not well prepared."[24] The spending he refers to includes the soaring costs of mandatory programs such as Social Security, Medicare, Medicaid, and interest on the national debt. He asserts that, absent any policy changes, these programs will consume an increasing percentage of US tax revenues leading to serious pressures on funding for discretionary programs such as national defense.

Social Security

Certain dates, such as 7 December 1941 and 11 September 2001, mark defining moments in American history. Although few people can recall the significance of 15 October 2007, the actions of a single woman set into motion a series of events that will shape American budgets for the next century. Kathleen Casey-Kirschling became the first *baby boomer* to file for social security benefits. But, she won't be the only one for long. Experts estimate an additional 20,000 boomers will be eligible to file for social security benefits each day for the next 20 years—which equates to over 125 million new social security recipients during this period.[25]

According to the Congressional Budget Office, three key shifts in American demographics will greatly influence the long-term solvency of the Social Security program. First, millions of members of the baby boomer generation will reach retirement age in the next few decades, greatly expanding the overall number of retirees. Second, the average life expectancy of Americans is increasing, so they will draw benefits for a longer period of time. Third, fertility rates are expected to remain far below the levels of 1950s and 1960s further reducing the number of available workers to pay into social security.[26]

The economic impact of these shifts is staggering as this bow wave of retirees begins collecting social security. By 2017, the Social Security Administration (SSA) will begin paying out more in benefits than it collects in taxes and will start drawing down its trust fund assets (surpluses accumulated prior to 2017). By 2040, the trust fund assets will be exhausted and Social Security will lack the resources to pay all promised benefits. According to SSA actuaries, promised benefits exceed expected tax revenues by $13.4T when extrapolated over the indefinite future.[27] Yet, this is just the tip of the financial iceberg. As more boomers retire, they will also strain America's government sponsored health-care programs, Medicare and Medicaid.

Medicare and Medicaid

Our nation spends over $2T a year on medical healthcare, with the US government paying nearly one-third of these costs.[28] As a result, Americans are now living longer, healthier lives than at any time in our nation's history. Peter Orszag, director of the Congressional Budget Office, acknowledges America's aging population is putting increased demands on our nation's social programs. However, he attributes spiraling medical costs—not Social Security—as the primary factor behind the growth in entitlement programs.[29] Figure 2 clearly supports this claim.[30]

The combination of higher patient loads, skyrocketing medical costs, and unfunded mandates such as the Medicare drug program has put our nation's healthcare programs on an unsustainable fiscal path. The 2006 *Medicare Trustees'* report projects a $71T gap between Medicare's long-term unfunded obligations and anticipated receipts. This dwarfs Social Security's $13.4T deficit and is 14 times larger than the total amount of government debt held by the public.[31]

Medicaid, another federally funded program that provides medical assistance to low-income families and individuals, is experiencing cost growth similar to Medicare. Increased numbers of elderly, low-income citizens are also expected to turn to Medicaid to pay for non-hospital expenses such as long-term health care—yet another unanticipated, and unfunded, consequence of Americans living longer.[32]

The Effects of Chronic Deficit Spending or "Hey Buddy, Can You Spare a Dime?"

Somewhere along the last 232 years, our government lost its sense of financial stewardship. Concepts such as balanced budgets and fiscal responsibility fell out of vogue and were replaced by unconstrained government spending and never-ending campaigns for increased tax incentives. As a result, the US deficit for 2008 will be an estimated $430B to $480B.[33] When added to

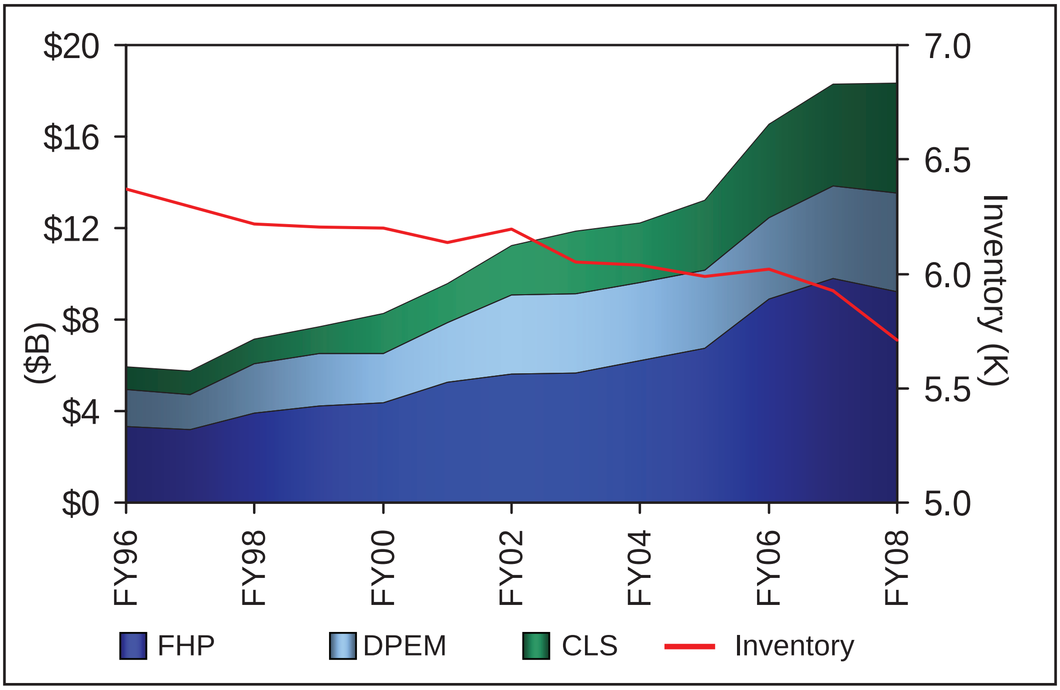

Figure 1. Increased cost of Aircraft Fleet

all prior deficits, the national debt totaled $10.7T as of 10 December 2008.[34] This debt, just like your home mortgage, accrues interest—which, according to the Treasury Department, totaled $451.2B in 2008.[35] To put this in perspective, interest on the US national debt accrues at a rate of roughly $51M per hour or nearly $1M per second.

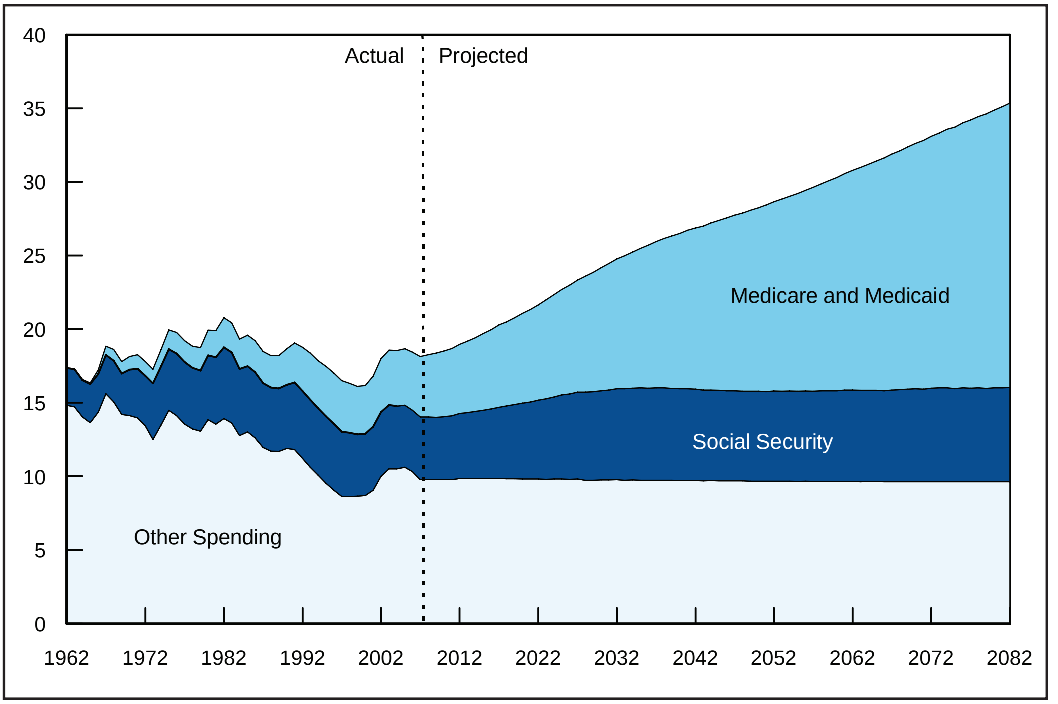

Figure 2. Long-Term Federal Spending Projection

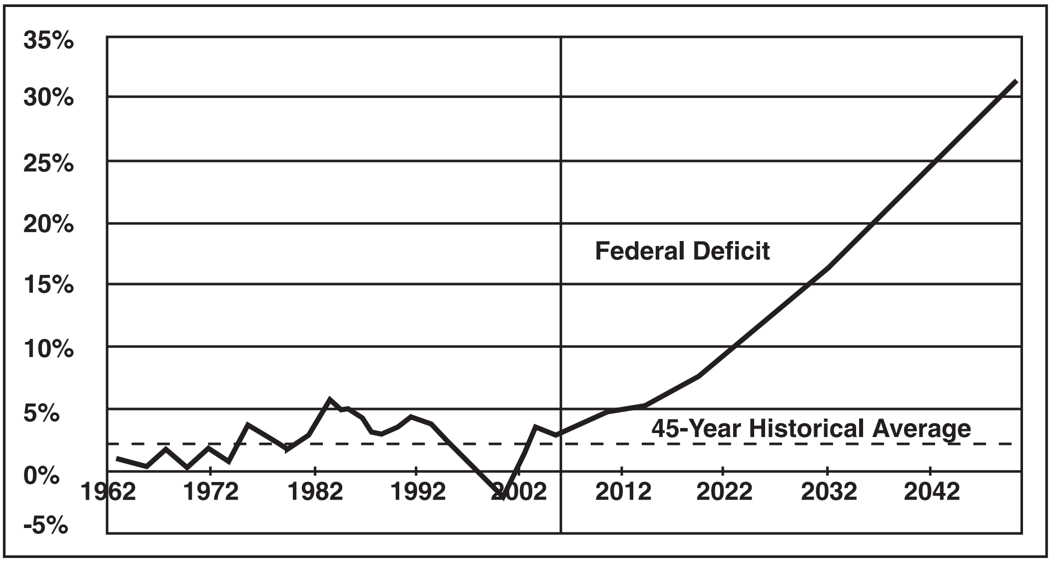

Figure 3. Federal Deficit as a Percentage of GDP

Short periods of deficit spending may be in the best interests of our country such as funding war costs or stimulating economic activity. However, studies indicate chronically large federal deficits reduce national saving, which slows the accumulation of national wealth and degrades economic performance.[36] The net result is lower future living standards. Over time, these deficits can also affect financial markets in the form of higher or lower interest rates, stock market values, and exchange rates.[37]

Since most lawmakers are reluctant to address our nation's fiscal imbalance by raising taxes or reducing spending, deficits will consume an increasing percentage of the US Gross Domestic Product (GDP). Figure 3 illustrates the projected trajectory of federal deficits.[38]

Because of mounting costs in mandatory programs—primarily Social Security, Medicare, and interest on the national debt—discretionary programs will come under increased pressure as Congress attempts to find ways to pay our country's bills.[39] An examination of the distribution of federal spending between mandatory and discretionary spending over the last 40 years is revealing. Spending on mandatory programs and net interest on the national debt increased from 33 percent of all federal spending to 62 percent between 1966 and 2006, while spending on discretionary programs dropped from 67 percent to 38 percent over the same time period (see Figure 4).[40]

A further breakdown of federal spending by major program in the same time frame clearly illustrates the explosive growth of spending for Social Security, Medicare, and Medicaid—and a corresponding reduction in defense spending from 43 percent of all federal spending to just 20 percent (see Figure 5).[41]

Although US spending patterns fluctuate due to changes in policy, the economy, and the security environment, one trend is clear—defense budgets will continue to come under pressure.

The US Defense Industrial Base

Since World War II, the US defense industrial base has converted America's economic might and intellectual capital into the advanced systems and technologies used by our military. The defense industry pioneered scientific breakthroughs in the 1950s and 1960s which played a significant role in such innovations as manned spaceflight, computers, and new manufacturing processes. Many of these technologies evolved into the state-of-the-art weapon systems seen today. However, as the US defense industry approaches the second decade of the twenty-first century, its position of dominance and ability to support our national defense is at risk, most notably from challenges related to industry consolidation, increased reliance on foreign made components, and surge capacity. These challenges, if left unaddressed, threaten the *strategic edge* created by this vital industry as well as its long-term viability.[42]

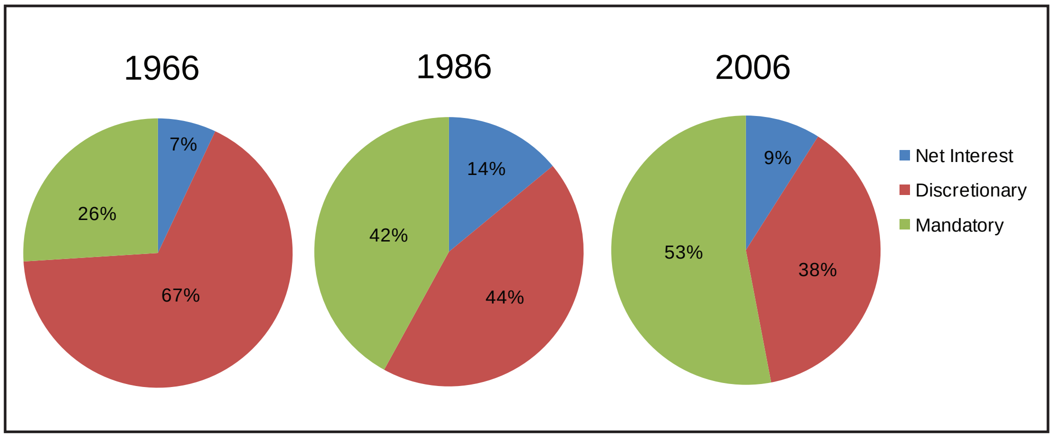

Figure 4. Federal Spending on Mandatory and Discretionary Programs

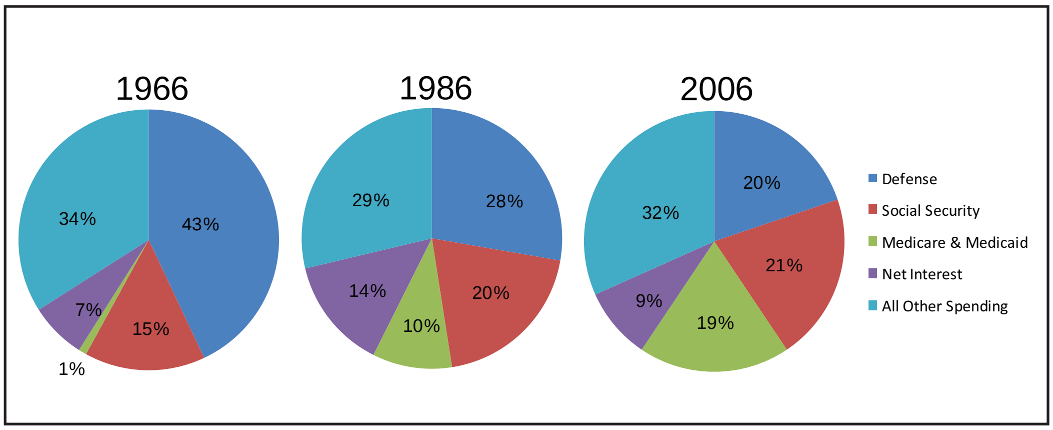

Figure 5. Composition of Federal Spending

The defense industry, like any other business venture, is shaped by the economic conditions within the marketplace—and the end of the Cold War was a seismic event. Between 1985 and 1997, military spending was slashed by nearly a third (in inflation-adjusted dollars) and procurement funding fell from 35 percent to less than 15 percent of overall defense funding.[43] This led to a period of intense consolidation and restructuring within the defense industry resulting in significantly fewer, but larger companies. According to one RAND study, the number of prime contractors in the US capable of manufacturing combat aircraft declined from seven to two during the 1990s. Similarly, only 4 of 14 missile manufacturers remained, while space launch vehicle producers fell from 6 to 2.[44]

Although the US government encouraged consolidation in the early 1990s as a way to retain critical industrial capabilities in a shrinking market, some officials expressed concerns over excessive consolidation.[45]

General Colin Powell, chairman of the Joint Chiefs of Staff at that time, warned "The number of producers and suppliers…of many of our critical military items is dwindling drastically, and is shrinking to unacceptably low levels."[46] His concerns were well-founded and prescient. A 2008 Government Accountability Office (GAO) report found 16 of 20 defense programs—including the B-2, F-22, and the Space-Based Infrared System-High—had supplier issues including component or technology obsolescence, fewer manufacturing sources, or production challenges.[47]

As the US industrial base contracted, the defense industry became increasingly dependent, and in some cases totally dependent, on foreign sources for key materials and components such as silicon, precision glass for reconnaissance satellites, and advanced fiber optics.[48] This raises concerns over the availability and trustworthiness of foreign-made products.[49] As one author points out, if shipments of imported parts to US defense contractors were stopped, the manufacturing lines of the American defense industry would grind to a halt.[50] Likewise, the US-Chinese Economic and Security Review Commission notes the United States' supply of *trusted* and *assured* microchips is in jeopardy due to the relocation of critical microelectronics manufacturing capabilities from the United States to other countries. They claim this opens the possibility that malicious software or "other unauthorized design inclusions may appear in unclassified integrated circuits used in military applications."[51]

Finally, the defense industry's surge capacity—the ability to rapidly ramp up research, development, and production rates—is another point of contention. Historically, America's ability to mobilize its manpower far outstrips its ability to equip them. For example, it took the US defense industry three years to reach its full capacity to produce aircraft and bombs during World War II and over two years to significantly increase deliveries during the Korean War.[52] Considering the equipment produced during these periods was relatively unsophisticated when compared to today's advanced systems, one can only speculate how long it would take for American's industrial base to ramp up production of F-35 fighters, Stryker vehicles, or aerial refuelers.

National Defense: A Necessary, but Expensive Undertaking

A billion here, a billion there; pretty soon you're talking real money.

—Senator Everett Dirksen, Illinois Senator, 1950 to 1969

National defense is a necessary, but expensive undertaking. Throughout history, countries have relied on their militaries to protect their people, sovereignty, and territorial integrity—a trend that continues today. Governments must recruit, equip, train, house, and feed military personnel; acquire and maintain weaponry and supporting infrastructure; and invest in emerging and future technologies to maintain an edge over their adversaries. This section provides a historical perspective on global military spending trends, US defense budget trends, and differing approaches for determining defense funding levels.

Global Military Spending Trends

There's a popular saying, "Freedom isn't free." This maxim certainly applies when it comes to the cost of national security. According to the Center for Arms Control, global military spending totaled $1.47T in 2008.[53] Based on their estimates, the United States is by far the global leader in military spending and accounts for 48 percent of the world's total military spending (see Figure 6 for breakout). Their analysis also indicates the US spends more than the next 45 highest spending countries in the world combined—5.8 times more than China and 10.2 times as much as Russia.

After trending downward after the end of the Cold War, global military spending is once again on an upswing. The Stockholm International Peace Research Institute, an international think tank for arms control, reports world military expenditures increased by a modest 1.5 percent per year (in inflation-adjusted terms) between 1996 and 2000 and jumped to 5.4 percent per year in the post-9/11 years.[54] At first glance, this gives the impression that other countries have ramped up their military spending and the global arms race is back under way. However, it should be noted that this spike is due largely to increased defense spending by the United States as it prosecutes the Global War on Terror (GWOT).

There are some positive developments associated with this uptick in worldwide military spending, one of which is more business for US defense contractors. Based on recently published statistics from DefenseNews, seven of the ten largest defense companies in the world are US-based companies.[55]

The annual 2007 defense revenues for the American companies totaled $156.5B, an increase of nearly 6 percent over 2006 levels. The United States also remains the largest arms exporter in the world with a 31 percent share of the global market, followed by Russia (26 percent), Germany (10 percent), France (9 percent), and the United Kingdom (4 percent).[56] On the other side of the transaction, the world's top five importers and their suppliers are China (Russia), India (Russia), UAE (France), Greece (USA), and South Korea (USA).[57]

US Defense Budget Trends

Historically, Department of Defense (DoD) budgets have risen and fallen based on the threats to our national security, the health of our economy, and policy decisions by American leaders. For example, after the United States emerged victorious from World War II in 1945, it rapidly demobilized its defense workforce from nearly 15 million military and civilian workers to only 2.2 million by 1948. Defense budgets were slashed by 85 percent over the same time frame.[58] Funding spiked upward and then reversed in the conflicts that followed—Korea, Vietnam, the first Gulf War, and today's GWOT. This cycle seems to repeat itself on a fairly consistent cycle of 18 to 20 years (see Figure 7).[59]

Over the same period, each Service's share of total defense funding remained remarkably constant—approximately one-third each.[60] Short-term deviations from this allocation occurred periodically based on changes in national defense strategy, such as nuclear deterrence in the 1950s. Increased spending on America's strategic nuclear triad—bombers, ICBMs, and submarines—resulted in a higher percentage of defense spending going to the Air Force and Navy. However, this funding shift proved to be short-lived and parity returned as Army funding increased during the heavily land- and sea-centric campaigns during the Vietnam era.

Beginning in the 1970s, a number of *defense-wide* agencies and activities were established to centralize certain functions or to serve the national command authority. Some of the better known *Ds* include the Defense Logistics Agency, Defense Intelligence Agency, and Defense Commissary Agency. In some cases, budgets for these agencies were carved from the Services' budgets, whereas new funding was appropriated for others. The net result is that defense-wide agencies' share of the overall defense budget increased from roughly 2 percent in 1948 to 16 percent in 2009. So, what do recent budgets look like?

The Bush Administration's annual budget requests for DoD's base budget (non-war costs) increased from $302B in fiscal year (FY) 01 to $515B in FY09—an increase of 71 percent. See Figure 8 for historical baseline and GWOT funding requests.[61] After adjusting for inflation, this represents a real growth rate of 34 percent over an eight-year period. This does not take into account supplemental funding for war costs or natural disaster relief operations. When war costs are included, then budgets more than doubled.

With defense budgets at record highs in dollar terms—exceeding $500B dollars a year—why can't the Air Force find the money to pay for modernization and recapitalization?

Findings from the Congressional Research Service (CRS) indicate that, despite large increases, the actual buying power across all of the Services is being eroded by four factors.[62]

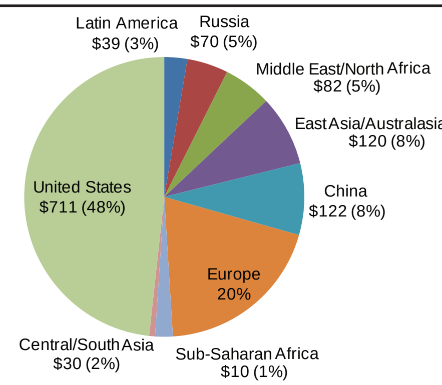

Figure 6. 2008 World Military Spending (In Billions)

Number	Company	2007 Defense Revenue ($B)
1	Lockheed Martin (US)	38.5
2	Boeing (US)	32.1
3	BAE Systems (UK)	29.8
4	Northrop Grumman (US)	24.6
5	General Dynamics (US)	21.5
6	Raytheon (US)	19.8
7	EADS (Netherlands)	12.2
8	L-3 Communications (US)	11.2
9	Finmeccanica (Italy)	10.6
10	United Technologies	8.8

Table 2. Top 10 Defense Companies in 2007

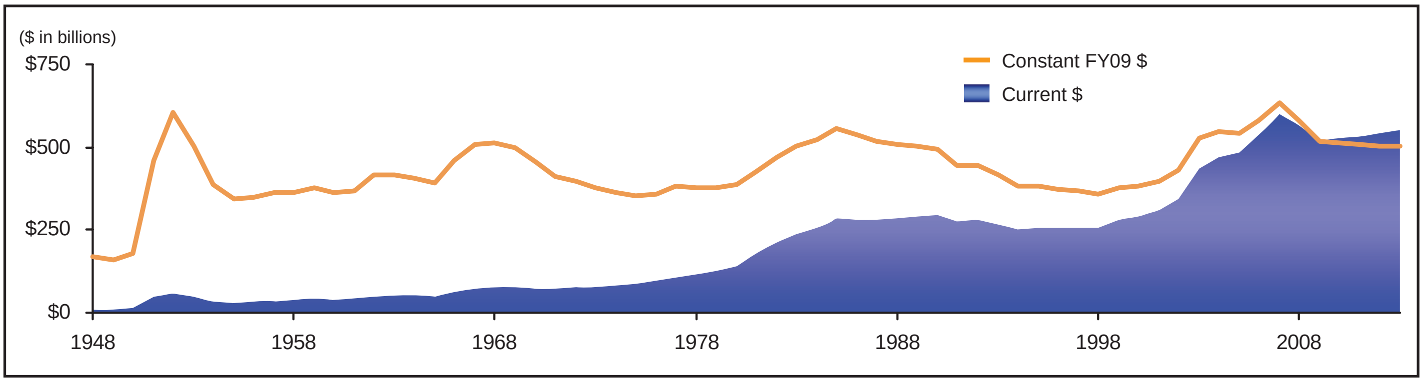

Figure 7. US Defense Budgets: 1948 - 2013

- Dramatically higher military personnel costs. The CRS calculates uniformed personnel now cost 40 percent more, after adjusting for inflation, than in FY99 because substantial increases in pay and benefits, including higher pay and housing allowances; TRICARE for Life; concurrent receipt; and large increases in bonuses.
- Operating costs continuing to grow above base inflation. Military operation and maintenance budgets, which pay for everything from flying training to weapons repair, is increasing approximately 2.5 percent above inflation. As a result, funds are moved from modernization and personnel accounts to pay for current operations.
- Increased cost growth in major weapons programs. Stealthy platforms, multi-mission ships, and advanced space systems are becoming more expensive, and at a faster rate, than earlier systems. Unless budgets increase more rapidly than costs, trade-offs between investment, personnel, and operating funds must be made.
- Poor cost estimates. The accelerating costs associated with new major weapons programs are exacerbated by poor cost estimates. This leads to major revisions in production schedules in an attempt to hold down cost growth.

Having personally served in the Air Force Financial Management career field for over 20 years, I have observed real-world examples of each of these factors. Cost growth in all areas—military and civilian payrolls, fuel for our air and ground fleets, utilities for our bases, and contract costs increases—forces hard trade-offs between investing in the future and paying today's bills. Unfortunately, the *urgency of now* usually takes priority, resulting in modernization and recapitalization being pushed further down the road.

Different Approaches for Determining Defense Funding Levels

Since it is impossible to simultaneously maximize national security and domestic spending, our nation's leaders are presented with the classic guns versus butter dilemma.[63] According to this basic economic concept, each tax dollar spent on national defense (guns) is one less dollar available for domestic programs (butter). As a result, elected officials are faced with a conundrum when they attempt to balance defense and domestic spending—too much butter puts our national defense at risk, whereas too little butter for their constituents jeopardizes the politician's reelection. In their search for balance, American leaders have considered a number of approaches for determining defense funding levels—the remainder method, quantitative/net assessment analysis, and most recently, pegging defense spending to a set percentage of GDP.

According to Richard Betts' article, "A Disciplined Defense: How to Retain Strategic Solvency," Presidents Truman and Eisenhower "calculated military spending using the 'remainder method': they started with the total tax revenues, subtracted out domestic spending, and gave whatever was left over to defense."[64] While this is a fairly straightforward approach, it is also quite arbitrary since it fails to take into account the security environment, potential adversaries, or overarching national security strategy. As one might expect, the funding was insufficient to properly arm and sustain America's military—a lesson we would learn during the Korean War.

After the Korean War, the focus shifted to a much more quantitative, net assessment-based approach. Secretary of Defense Robert S. McNamara and his group of whiz kids introduced the arcane world of operations research and advanced modeling in an attempt to quantify defense funding needs. McNamara instituted the Planning, Programming, and Budgeting System, a forerunner to today's Planning, Programming, Budgeting, and Execution System. This system provided a more formalized approach for linking defense plans to resourcing activities and has been used by DoD for the last 40 years. However, time marches on and defense officials began pondering a third approach about two years ago.

Because of concerns over current and future defense funding levels, several senior military officials and prominent think tanks began advocating proposals linking defense budgets to a specific percentage of the GDP (usually a minimum of 4 percent). In *Foreign Affairs* magazine, Senator John McCain wrote, "America could afford to spend 4 cents of every dollar, or more on national defense." Others jumped on the bandwagon, including the Secretary of Defense, the Chairman of the Joint Chiefs of Staff, and even the Air Force Chief of Staff. The argument was simple and the evidence was compelling—US defense spending, as a percentage of GDP, had fallen to historically low levels and our national defense was increasingly at risk (see Figure 9).[66]

Unfortunately, this proposal is too simplistic and lacks rigor. First, America's GDP has expanded rapidly over the past several decades and is now 6 times larger than in the 1950s (in inflation adjusted terms).[67] If, as one writer notes, the United States devoted 37 percent of its GDP to defense now, as it did during World War II, defense spending in today's dollars would approach $5T per year.[68] Likewise, if America fell into a prolonged recession, it is unlikely defense officials will agree to lower budgets for an undetermined period. Ultimately, this proposal's most damning flaw—common to each of the approaches reviewed—is that it focuses on the amount of funding defense should receive and not the more critical question, "How much is enough?"[69]

Conclusions and Recommendations

Let every nation know, whether it wishes us well or ill, that we shall pay any price, bear any burden, meet any hardship, support any friend, oppose any foe to assure the survival and the success of liberty.

—John F. Kennedy, Presidential Inaugural Address, 20 January 1960

The year was 1958. Nikita Khrushchev was the Soviet Union premier, Sputnik 2 orbited earth, and US bombers loaded with nuclear weapons trained in the skies above America. As the Cold War heated up, the US Subcommittee on Economic Policies for National Security was commissioned to answer the question, "How much can America afford to spend on national defense?" After engaging the brightest minds in our country, the esteemed panel responded with a simple answer: "America can afford what it has to afford."[70]

This answer is just as relevant today as it was 50 years ago. Our country will spend whatever is deemed necessary for our national defense. At this juncture in time, American policymakers and their funding priorities are being shaped by immediate challenges—the cost of ongoing operations in Iraq and Afghanistan, the housing market meltdown, and the paralyzing effects of a global credit crisis. In this environment, the Air Force is unlikely to secure the prerequisite Congressional funding support for an aggressive modernization program.

Modernizing the Air Force is not an affordability issue. Our lawmakers have proven to be immensely successful with spending significantly more money than they receive from taxpayers as evidenced by the $700B bailout plan and looming financial crises posed by Social Security, Medicare, and the national debt. It is a matter of national priorities. The time has come for America's leaders and citizens to address "our nation's growing fiscal imbalance and changing security environment."[71] This is no simple task, but unless American leaders address structural domestic issues—specifically, unchecked entitlement growth and a shrinking US defense industrial base—our nation's ability to effectively

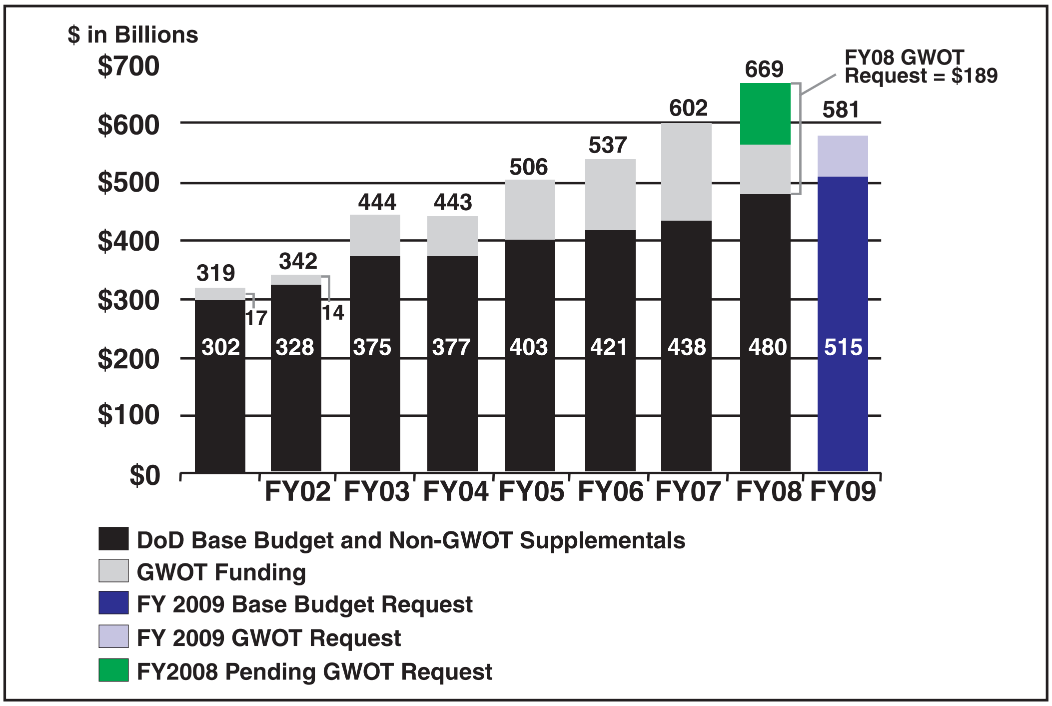

Figure 8. Historical DoD Budget and GWOT Funding

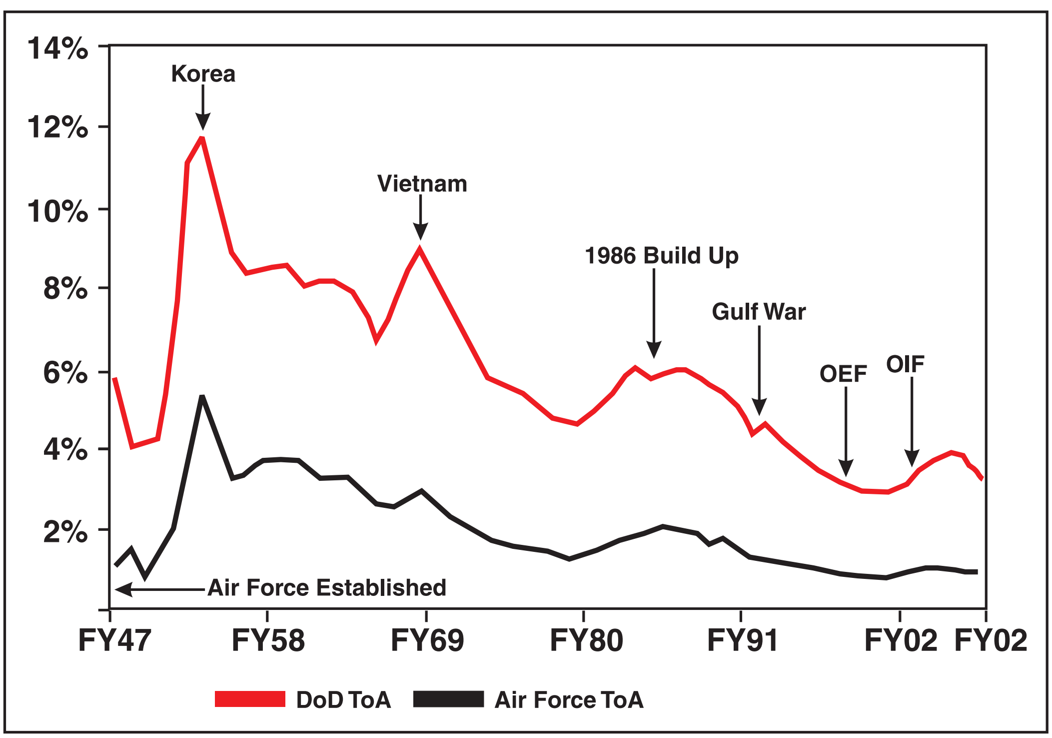

Figure 9. DoD and Air Force Budgets as Percent of GDP

counter future threats is at risk. Based on the insights gained during this research effort, the following recommendations are provided as a guide to help put our nation on a more fiscally sustainable path—one, that if pursued, will ensure that the United States has sufficient monetary resources and industrial capacity to support Air Force modernization and recapitalization efforts.

Recommendation Number 1. Reassess America's national security policy and the role of the military (and other instruments of national power) in the new security environment. America's military can do just about anything, but it cannot do everything. Our leaders must apply the first rule of management—balancing commitments with resources. This will require a realistic assessment of the threat environment and global commitments, clearly defining the roles and mission of each instrument of national power, and adequately resourcing these functions. To better synchronize priorities with resources, I recommend establishing a unified security budget for key players involved in providing national security. This would include the Departments of Defense, State, and Homeland Defense, along with others, as deemed appropriate. The Department of Defense may lose some budget authority as part of this rebalancing process; however, since our national security is based on the skillful application of both hard and soft power, this may be the most efficient and effective use of limited funds.

Recommendation Number 2. Restore fiscal balance through prudent spending cuts and more effective tax policies. A strong economy is a prerequisite for a strong military. Unfortunately, our country and economy is on an "unsustainable fiscal path" that will ultimately impact our national security according to David Walker, the former Comptroller General of the United States.[72] No politician in his or her right mind wants to propose cutting entitlements or raising taxes, yet this is precisely what must be done to rein in America's out of control budget—and the sooner the better. The longer we wait to address deficit spending and the tsunami wave of Social Security and Medicare bills bearing down on our country, the more drastic future cuts will have to be. Politicians should consider increasing the minimum age for drawing Social Security, repealing the Medicare drug care program, and reevaluating tax policies (to include reversing prior tax cuts or abolishing the IRS and substituting a national sales tax for personal income taxes).

Recommendation Number 3. Pursue a long-term strategy for revitalizing the US defense industrial base. The government should identify those critical skills, technologies, and manufacturing capabilities that are needed to ensure the long-term viability and technological superiority of our nation's defense industrial base. This will require a sustained effort spanning decades and considerable investment, but the potential benefits to our nation are substantial. First, it encourages the development of more scientists and engineers which increases America's intellectual capital. Second, domestic production creates more jobs which contribute to the nation's overall wealth. Finally, and most importantly, it provides an opportunity for America to regain its position as a leading manufacturer among world producers.

There are no simple solutions to the economic challenges facing our country and the affordability issues surrounding the Air Force's modernization and recapitalization requirements. In the final analysis, affordability (like beauty) is in the eye of the beholder. If, and when, our country's leaders feel our nation's air and space dominance is significantly threatened, they will spend whatever is needed. Let's just hope they are not too late.

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71. Walker, 1.
72. Walker, 61.

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http://www.aflma.hq.af.mil/lgj/journals.asp

Defining Logistics

The word logistics entered the American lexicon little more than a century ago. Since that time, professional soldiers, military historians, and military theorists have had a great deal of difficulty agreeing on its precise definition. Even today, the meaning of logistics can be somewhat *fuzzy* in spite of its frequent usage in official publications and lengthy definition in Service and Joint regulations. Historian Stanley Falk describes logistics on two levels. First, at the intermediate level:

> Logistics is essentially moving, supplying, and maintaining military forces. It is basic to the ability of armies, fleets, and air forces to operate—indeed to exist. It involves men and materiel, transportation, quarters, depots, communications, evacuation and hospitalization, personnel replacement, service, and administration.

Second, at a higher level:

> Logistics is the economics of warfare, including industrial mobilization; research and development; funding procurement; recruitment and training; testing; and in effect, practically everything related to military activities besides strategy and tactics.

While there are certainly other definitions of logistics, Falk's encompassing definition and approach provides an ideal backdrop from which to examine and discuss logistics. Today, the term combat support is often used interchangeably with logistics.

The Editors, *Air Force Journal of Logistics*

The Themes of US Military Logistics

From a historical perspective, ten major themes stand out in modern US military logistics.

- The tendency to neglect logistics in peacetime and expand hastily to respond to military situations or conflict.
- The increasing importance of logistics in terms of strategy and tactics. Since the turn of the century, logistical considerations increasingly have dominated both the formulation and execution of strategy and tactics.
- The growth in both complexity and scale of logistics in the 20th century. Rapid advances in technology and the speed and lethality associated with modern warfare have increased both the complexity and scale of logistics support.
- The need for cooperative logistics to support allied or coalition warfare. Virtually every war involving US forces since World War I has involved providing or, in some cases, receiving logistics support from allies or coalition partners. In peacetime, there has been an increasing reliance on host-nation support and burden sharing.
- Increasing specialization in logistics. The demands of modern warfare have increased the level of specialization among support forces.
- The growing tooth-to-tail ratio and logistics footprint issues associated with modern warfare. Modern, complex, mechanized, and technologically sophisticated military forces, capable of operating in every conceivable worldwide environment, require that a significant portion, if not the majority of it, be dedicated to providing logistics support to a relatively small operational component. At odds with this is the need to reduce the logistics footprint in order to achieve the rapid project of military power.
- The increasing number of civilians needed to provide adequate logistics support to military forces. Two subthemes dominate this area: first, unlike the first half of the 20th century, less reliance on the use of uniformed military logistics personnel and, second, the increasing importance of civilians in senior management positions.
- The centralization of logistics planning functions and a parallel effort to increase efficiency by organizing along functional rather than commodity lines.
- The application of civilian business processes and just-in-time delivery principles, coupled with the elimination of large stocks of spares.
- Competitive sourcing and privatization initiatives that replace traditional military logistics support with support from the private business sector.

The Editors, *Air Force Journal of Logistics*

Integrity is the fundamental premise for military service in a free society. Without integrity, the moral pillars of our military strength, public trust, and self-respect are lost.

—Gen Charles A. Gabriel, USAF

No form of transportation ever really dies out. Every new form is an addition to, and not a substitution for, an old form of transportation.

—Air Marshal Viscount Hugh M. Trenchard, RAF

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We now know the dominant weapons on the battlefield are the ones that can be mass-produced, operated by motivated fighters, kept in action with spares and supplies, and used in concert with other weapons. In the words of General George S. Patton, "How easily people can fool themselves into believing wars can be won by some wonderful invention rather than by hard-fighting and superior leadership."

Rewind

Readings in Logistics

From Production to Operations: The US Aircraft Industry, 1916-1918
Logistics Lessons from the Past—Deployed Operations
German Wonder Weapons: Degraded Production and Effectiveness
A Historical Perspective on the Future of Military Logistics
The Logistics Constant Throughout the Ages

In this edition of the *Air Force Journal of Logistics* we begin a new feature—"Rewind: Readings in Logistics." This continuing feature will present articles and essays previously published in an edition of the *Air Force Journal of Logistics* or one of the Journal-produced books or monographs. The feature will include articles that encompass three areas: historical perspectives, contemporary thought, and studies and analyses. Both the current and future content of the feature were selected for two basic reasons—to represent the diversity of ideas and to stimulate thinking. That's what we hope you do as you read the material. Think about challenges. Think about the lessons history offers. Think about why some things work and others do not. Think about problems. Think about organizations. Think about the nature of logistics. Think about fundamental or necessary logistics relationships. Think about the past, present, and future.

The feature also provides a convenient source of material for mentoring and discussing logistics and logistics issues with new Air Force logisticians.

All of the articles and essays for "Rewind" in this edition were published in *Thinking About Logistics 2009,* Air Force Logistics Management Agency, Maxwell Air Force Base, Gunter Annex, July 2009. Copies of *Thinking About Logistics 2009* may be obtained free of charge from the Journal staff.

Lieutenant Colonel Andrew W. Hunt, USAF

From Production to Operations: The US Aircraft Industry, 1916-1918

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.

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

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.)

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 (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 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.

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.

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]

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 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.

Perhaps one of the biggest obstacles facing the military in the pursuit of airplane production was the lack of experience in the logistics arena.

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 WWI 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.

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

Raw materials are the first key to production and, therefore to any logistics operation.

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, 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.

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 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 machine guns in the nose and two .30-caliber Lewis machine guns 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.

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]

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.

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.

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. 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]

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.

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]

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, 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

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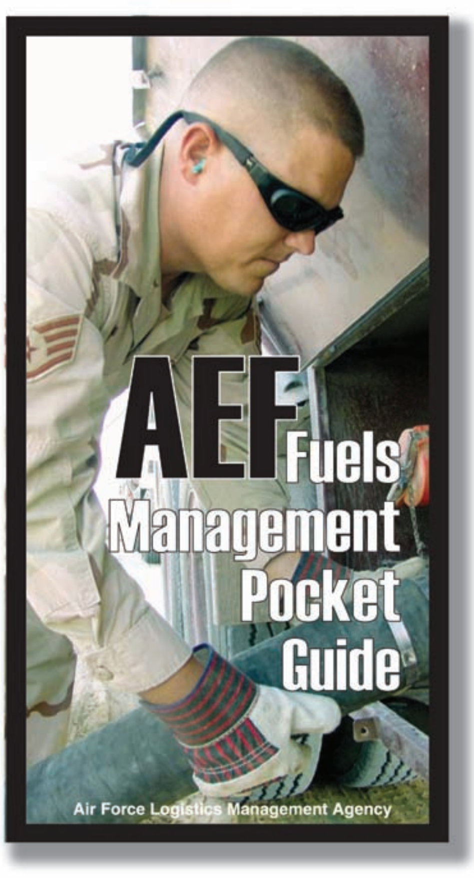

operations (the Inland Traffic Service) provided the military with the means to transport large amounts of men and materiel in a timely manner. Overseas shipping capabilities lacked, initially, but were soon made sufficient through appropriation of a larger fleet and international cooperation. By the end of the war, the techniques used to deliver troops and cargo were among the best available.

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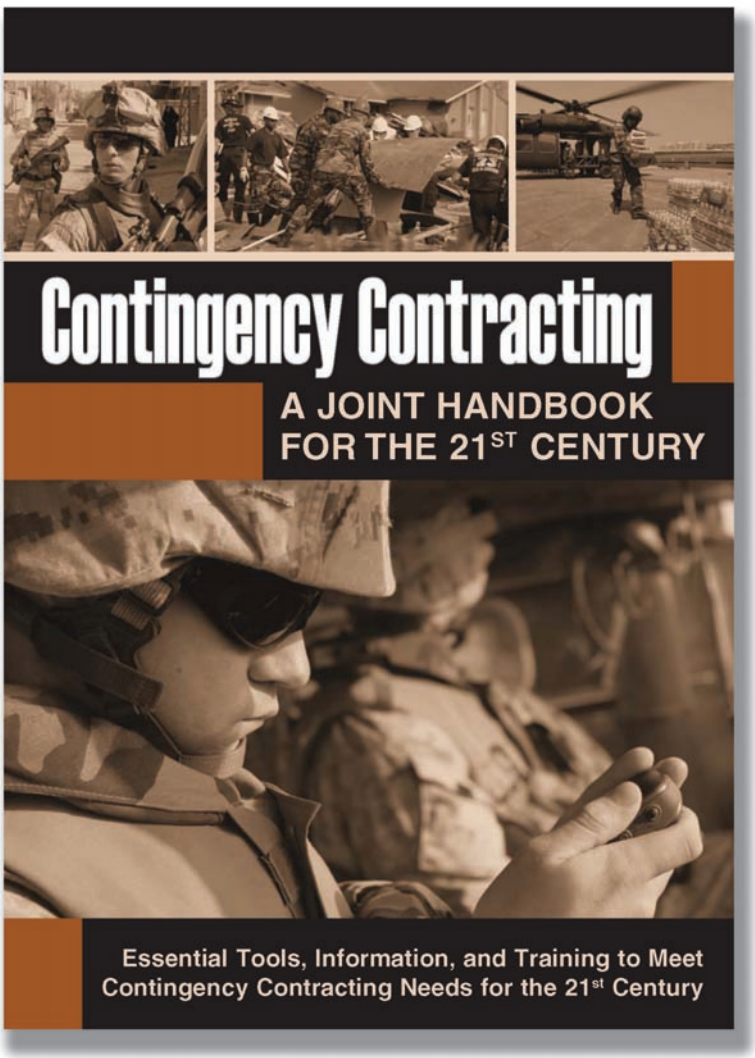

Contingency contracting support has evolved from purchases under the simplified acquisition threshold to major defense procurement and interagency support of commodities, services, and construction for military operations and other emergency relief. Today, this support includes unprecedented reliance on support contractors in both traditional and new roles. Keeping up with these dramatic changes, while fighting the Global War on Terror, is an ongoing challenge.

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Generating Transformational Solutions Today; Shaping the Logistics Enterprise of the Future

Air Vice-Marshal Peter J. Dye, RAF

Logistics Lessons from the Past—Deployed Operations

Wot makes the soldier's 'eart to penk, wot makes 'im to perspire? It isn't standin' up to charge nor lyin' down to fire; But it's everlastin' waitin' on a everlastin' road; For he commissariat camel an' is commissariat load.

Northern India Transport Train—Barracks-Room Ballads
—Rudyard Kipling

Logistics is not so much a science as an art and yet, under the pressure of tighter budgets and downsizing, there is great temptation to adopt the view that sophisticated resource modeling and realistic simulation (including wargaming), together with careful staff work, are sufficient in themselves to provide for effective support of deployed operations. But anyone who has had to maintain aircraft or other complex weapons systems, whether at home or overseas, will know how the unexpected can rapidly degrade effectiveness, notwithstanding the resources available, or the depth and detail of the advance planning.

I am not suggesting we cannot continue to use the techniques mentioned above (and others) to control costs and improve our logistics support. However, much of our recent experience relates to a scenario that increasingly appears to have been driven by an exceptional period in world affairs. Whether we like it or not, our current methods of doing business largely reflect the lessons learned in the Cold War and are tailored to supporting the main base concept. Of course, we cannot simply abandon tried and tested procedures, but we are entering a period of radical change and a concept of operations that owes more to the Royal Air Force's (RAF) experience up to 1945 than the subsequent 50 years of *peace*. Recent studies have addressed the RAF's conceptual framework for developing its capabilities to deal with new realities. Nevertheless, it is very much new territory, with few examples and little practical experience to draw upon. That being so, I would suggest there is considerable merit in looking at how the RAF supported deployed operations in the first half of this century, as part of the ongoing process to develop our post-Cold War logistics strategy.

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To those who suspect my thesis implies things were done better in the past—that there was a sort of logistics golden age—note the deployment in 1916 of the No. 29 Squadron to join the Expeditionary Force. No. 29 Squadron had been formed at Gosport from the No. 23 Squadron in November 1915. Towards the end of January 1916, 20 DH-2 Scouts were allotted to the new squadron. It was decided (somewhat rashly as events proved) to deploy the ground crew and support personnel, together with the squadron transport, ahead of the aircraft move. The former proceeded overseas on 14 March. Ten days later, the aircraft set off for Dover, but mechanical problems (exacerbated by inexperience with the new aircraft, the fact that the squadron had been largely without ground crew for nearly 2 weeks, whilst most of those remaining had contacted measles), poor weather, and accidents en route meant that by the second week of April only 12 machines had actually reached France. The overall attrition was even worse than one might suppose, since the original allocation of 20 aircraft had been supplemented by further deliveries direct from the manufacturer (but none with compasses fitted, which raised some concerns amongst those pilots, who had managed to reach Dover, as to the wisdom of a Channel crossing).

Headquarters Royal Flying Corps (HQ RFC) subsequently calculated that, "the total number of machines consumed, in order to deliver at St Omer 12 serviceable, was 27."[1] The majority of these were scattered around Southern England, some written-off, whilst others ditched in the Channel or crashed on landing in France. The pilots involved fared little better, suffering their fair share of injuries, as well as measles, such that the last arrived in France over 2 weeks later. All in all, it was not one of the RFC's finest hours.

Whilst this catalogue of disasters may be entertaining at this distance, I doubt there are any fundamental lessons to be learnt. However, there are aspects of RAF deployed operations in the Second World War that are actually quite instructive.[2] One example is the logistic support for the RAF elements involved in Operation TORCH, the North African landings that took place in December 1942. Some 450 aircraft were involved in the Eastern operation, centred on Algiers, tasked with providing air cover for the shipping and ground forces, and, once ashore, to protect against air attack and to support the subsequent land advance. Immense difficulties were encountered as this was the first large-scale amphibious landing to be undertaken by the Allies. It was also the first real test of Anglo-American cooperation, the conduct of joint operations and, most importantly, of joint planning. As far as the air element was concerned, it was agreed that the Army would provide fuel and weapons, whilst the RAF would furnish all support vehicles, ground equipment, and technical stores. The relevant equipment was packed at maintenance units in the UK to schedules prepared by the Air Ministry, but the sponsoring branches had no visibility of what was actually provided. It was subsequently reported by the units making up the packs that there were 72 percent inabilities. All *pack-ups* were allocated, in the interests of security, field unit serial numbers. The code for these numbers was given a very limited distribution and not included in the administrative instructions. All stores were then loaded at UK ports for travel by convoy directly to join the Eastern Task Force at Gibraltar.

The variety of aircraft and engine types vastly increased the difficulty of supply and repair at the school. More significantly, however, the RAF embarkation staff of 26 personnel of all ranks was quite incapable of sorting the mountains of equipment being discharged.

The actual landings met little opposition and the advance RAF ground parties were able to reach their designated airfields and receive the first Allied aircraft by 1030 on the morning of D Day. Thereafter matters got more difficult. Enemy air attacks commenced in earnest, fuel was in extremely short supply, and essential equipment either did not arrive at the beachhead or was lost on landing (this problem was exacerbated by the limited attention that had been paid to the loading of the ships in the UK such that in some cases it took 2 days to unload priority equipment). It would be wrong to suggest the planners had not anticipated the difficulties likely to be faced in landing large quantities The variety of aircraft and engine types vastly increased the difficulty of supply and repair at the school. More significantly, however, the RAF embarkation staff of 26 personnel of all ranks was quite incapable of sorting the mountains of equipment being discharged. The result was not only were the docks swamped with piles of stores which in fact would not be needed for many weeks, but there was also no means of distinguishing between cases. A great deal of unnecessary equipment found its way to the forward areas in place of items that were urgently required. To make matters worse, although the consumption of ordnance was far less than had been anticipated, the early consignments of bombs arrived with the wrong components or without components at all; this included fusing links. By the end of January the process of marrying up bombs with tails had still not been completed satisfactorily (without wishing to exaggerate, there are echoes of our own experience during Operation GRANBY). There was also the usual share of unexpected, and hence unplanned, maintenance problems. For example, the soft state of the airfields following heavy rain resulted in a large number of aircraft ground looping and breaking their propellers, therefore stocks were rapidly exhausted.

Logistic problems did not end here. The numbers of RAF movements staff were totally inadequate to the task and thus had to rely upon Army movements personnel. But without the key to unit serial numbers, the latter could only surmise for whom the equipment was intended. This generally ended in it being sent to the wrong unit, who, knowing only its own serial number, could not dispose of the equipment to its proper destination. As a result, much of the equipment off-loaded from the first convoy into Algiers did not reach the correct units until many weeks had elapsed. Finally, when the pack-ups were opened it was often found the items required were either missing or present only in reduced quantities.

Those involved in the handling of stores at Al Jubayl during Operation GRANBY nearly 50 years later many have noticed some similarities between their experiences and the problems encountered in Operation TORCH. In neither event was there effective enemy action to interrupt the supply chain and yet immense difficulties were encountered simply as a result of the scale and pace of the buildup, the sheer volume of stores and the almost impossible task of locating specific equipment amongst the countless crates and International Standards Organisation (ISO) containers on the dockside. One is forced to conclude that moving thousands of tons of stores across a continent has always been the simplest (but not necessarily the easiest) part of any logistic operation. My personal experience during Operation GRANBY would suggest, however, that even this statement has to be qualified. I recall on one occasion a serviceable aeroengine, urgently required at Muharraq, returning from Lyneham on the same lorry that had rushed it down there—much to the distress of the driver. More importantly, the original inbound unserviceable engine was at that very moment winging its way back to the Gulf in the back of a Hercules! To be blunt, delivering the required item, to the right hands, at the right place and at the right time, remains the overriding challenge for any logistic organisation. It is also true that forging the last link in the support chain can be as difficult as assembling the remainder. It is a task made all the more challenging in a joint multinational environment, subject to the vagaries of host-nation support and the inevitability of unplanned (and hence inadequately provisioned) unserviceabilities. The way ahead must surely lie in both improving asset tracking and also providing greater visibility of the supply chain to all parties, including the consumer as well as the supplier.

One of the unique aspects of the RAF's logistic planning for Operation TORCH was the creation and employment of servicing commandos. These units comprised up to 150 RAF tradesmen, with intensive combat training, who were to be landed during the assault phase and would be capable of defending themselves (and their aircraft), whilst also undertaking the daily servicing, refueling and rearming of aircraft operating from advance landing grounds and captured airfields until such time as the main squadron servicing parties arrived. In theory, the servicing commandos—although entirely comprised of Trade Group 1 (technical) personnel—could only provide rudimentary support as their tools and equipment would be necessarily limited. However, the two servicing commandos employed during Operation TORCH had to undertake the maintenance of many more squadrons, of several aircraft types, and for a considerably longer period than originally intended owing to the difficulties outlined above as well as problems in assembling and moving the appropriate technical personnel forward. In fact, instead of being relieved after a few days, they were employed continuously for 5 weeks without rest.[3] Notwithstanding the servicing commandos' efforts, the lack of maintenance facilities and skilled personnel soon began to make itself felt in the form of reduced aircraft serviceability. This is not to say the logistic planning had failed to make provision for the sustained support of aircraft operations, but it had been envisaged that the majority of squadrons once ashore would be rapidly joined by their assigned maintenance personnel, as well as air stores parks (with sufficient equipment to support 30 days' maintenance) and repair and salvage units. Quite deliberately there had been no provision for major repair (beyond what the repair and salvage units could undertake) in the anticipation of a relatively brief campaign. In the event, the operational commanders decided to accelerate the aircraft deployment plan and this, coupled with the supply chain difficulties already outlined, meant squadrons were compelled to operate for some time without support equipment, adequate servicing and repair arrangements, or even transport and signals support. Typical of these difficulties was the plight of the two Beaufighter night fighter squadrons called forward 3 weeks early. On arrival they had to be maintained by members of the aircrew, co-opted ground personnel from a collocated Hudson squadron, and mechanics from a repair and salvage unit. To compound these problems, the Beaufighters' radar equipment had been removed for security reasons and sent by sea with the ground personnel. Therefore, an emergency supply of radar equipment had to be flown out direct from the UK before night fighter operations could commence. But, not surprisingly, the hastily assembled maintenance team found the radar extremely difficult to install without any specialist knowledge or the appropriate support equipment and tools.

This is not to say the logistic planning had failed to make provision for the sustained support of aircraft operations, but it had been envisaged that the majority of squadrons once ashore would be rapidly joined by their assigned maintenance personnel, as well as air stores parks (with sufficient equipment to support 30 days' maintenance) and repair and salvage units.

Eventually, the second line maintenance units were able to come into action, but this did not immediately resolve every problem. The repair and salvage units found they faced an immense backlog of repairs because of the delays and were effectively immobilised whilst the stores parks discovered the storage space provided by the Army was but a fraction of their actual requirements. Eventually some additional space was found in local farm buildings. Strenuous efforts were made to recover this situation as the campaign developed by improving both the support arrangements as well as the mobility of the squadrons. Maintenance personnel in the forward area were reduced to a minimum to enable the squadrons to be placed on a mobile basis capable of movement at short notice utilising their own motor transport. The remaining maintenance personnel were withdrawn to the rear echelons. The forward stores parks were also reduced to *immediate issue* stocks only (and the personnel reduced accordingly), whilst the repair and salvage units were totally withdrawn, other than small mobile sections to work with the squadrons. In general, these new arrangements worked well and would provide the pattern for all subsequent campaigns.

Amongst the many other lessons learnt from Operation TORCH was the need to schedule carefully the arrival of equipment and stores, whilst ensuring the necessary personnel and repair facilities were in place as early as possible to permit effective air operations. That said, it was also clear too large a forward support organisation would take a disproportionate share of the available shipping and assault craft, whilst also serving to hinder subsequent mobility. Exercises undertaken in the UK during 1943, in preparation for the Normandy landings, confirmed the overriding importance of reducing what might today be referred to as the *deployment footprint*. In fact, how best to organise the maintenance support for squadrons whilst enhancing their mobility, was a question which group and command staffs had been struggling with since 1940. Prior to the expansion of the RAF, fighter squadrons were largely self-sufficient, each flight having the capability to undertake in-depth repair, as well as the normal servicing functions. It was soon evident this system could not cope with the increased flying rate and greater technical complexity that accompanied the expansion programme. As a result, maintenance support was reorganised on a squadron basis; two flights being responsible for servicing tasks, whilst the third flight undertook major repair work and the deeper inspections. This system, which today we would probably describe as an *autonomous* maintenance organisation, remained in force for the first year of the war. However, during the Battle of Britain it was discovered that the mobility of squadrons was adversely affected and the frequent squadron moves resulted in the maintenance personnel being increasingly detached from their units, sometimes being spread over at least three different stations.

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In an endeavor to improve the mobility of the squadrons and avoid the need to transport large ground parties and redundant bulky equipment from station to station, it was decided to reexamine the maintenance system. After toying with a proposal to do away with all maintenance personnel and rely entirely upon station support (the *centralised* approach), it was agreed a *semiautonomous* organisation should be adopted, whereby the bulk of the repair responsibility, associated tradesmen and ground equipment would be transferred to the station *maintenance party*, leaving only sufficient squadron maintenance personnel to conduct daily servicing and minor inspection tasks. The squadron engineer officer would remain in the squadron but the station maintenance party would provide echelons attached to each squadron, albeit under the command of the station engineer officer. These echelons could also provide a mobile unit to accompany the squadron for *bare-base* moves.

Over the next few years this organisation was further developed to become almost fully centralised; the supporting technical personnel were in effect entirely divorced from the flying squadrons. A three-tier structure was introduced comprising: (1) the *Advanced Landing Ground*, where quick turnaround servicing would be carried out by servicing commandos (as already described); (2) the *Airfield Area*, capable of supporting three squadrons where servicing was fully centralised under the station maintenance party; and (3) the *Base Area* that undertook maintenance beyond the station maintenance party's capability or capacity to complete in under 48 hours. The Airfield Area was in essence a mobile station, but to achieve this it was necessary to create additional support units, including repair and salvage units and forward stores parks. This system was extremely successful in providing effective support to the RAF's flying squadrons, both through the North African and Italian campaigns as well as during and after the Normandy landings. It should be noted that, notwithstanding the centralised maintenance organisation, particular efforts were made to sustain squadron identity by affiliating Airfield Area echelons to specific squadrons under a squadron technical officer. This also served to improve the welfare and management of the technical personnel concerned. That said, such pragmatism was not allowed to detract from the overall policy of centralisation.

As a footnote, the sort of problems experienced by the No. 29 Squadron in 1916 were resolved by making temporary provision at the base airfields in Southern England for maintenance support, while the squadron servicing personnel established themselves in Normandy. In the event, the maintenance arrangements worked extremely well. The first servicing commandos landed on D+1 and received their initial aircraft on D+2 (on a temporary basis, for refueling and rearming). By the afternoon of D+3 some 3,500 RAF personnel and 815 vehicles had been landed. The permanent move of fighter squadrons to airfields in Normandy commenced on D+4, once the Airfield Areas were ready to receive them. Thereafter the pace of deployment accelerated such that, by the end of June, one wing was arriving every 5 days. Once again, the servicing commandos had proved invaluable, not only enabling damaged aircraft to return back to base, but also ensuring an extremely high availability rate. Nevertheless, once the bridgehead was established and the Airfield Areas in theatre, their importance rapidly declined and they were withdrawn at the end of July.

As in Operation TORCH, a number of environmental maintenance problems arose. Rather than wet airfields, the cause in this instance was dust. The soil on which the landing grounds were constructed contained a very high proportion of silica which lessened the life of engines, particularly those not fitted with air-cleaning devices (such as the Typhoon's Sabre). Unserviceabilities rapidly rose and it was only by pumping oil and water onto the airfield surface and minimising warm-up times that the problem could be contained (but not before 66 engines had been damaged beyond repair). There are echoes again here of the RAF's experience in Operation GRANBY. I would only add that maintaining sophisticated aircraft and weapons systems outside of their normal operating environment is something that has to be practised. Careful planning, experience, and foresight are not a substitute for the real thing!

Following the Normandy breakout, the primary problem facing the maintenance organisation was the ever lengthening lines of supply. Transport aircraft were used to supplement the supply chain and, in particular, to deliver aviation fuel to help support the momentum of the advance. This was successful, and at no stage were operational units ever prevented from carrying out sorties for lack of supplies. In order to avoid bottlenecks and minimise forward storage requirements, the provisioning system was based upon a *call-forward* principle, rather than the base organisation sending supplies into the theatre at will. This has clear parallels to today's concept of *just-in-time* supply and express chain management.

Turning to the lessons we might draw today, I would first observe that the RAF's organisational structure to support deployed and mobile aircraft operations in the Second World War took some four years to perfect. The result was a lean, efficient system that: sustained high availability; enhanced squadron mobility, flexibility and economy in manpower and equipment; and enabled squadron commanders and airmen to concentrate on their operational responsibilities.

Turning to the lessons we might draw today, I would first observe that the RAF's organisational structure to support deployed and mobile aircraft operations in the Second World War took some 4 years to perfect. The result was a lean, efficient system that: sustained high availability; enhanced squadron mobility, flexibility and economy in manpower and equipment; and enabled squadron commanders and airmen to concentrate on their operational responsibilities.[4] It may well be the servicing commando concept—given the remote possibility we will again be required to participate in an amphibious assault on a hostile shore—will remain simply an historical curiosity. Nevertheless, and notwithstanding the passage of time and subsequent technological development, the lessons of 1939-1945 provide much food for thought in deciding how best to develop logistics support. Do we really have the right maintenance organisation to cope with the post-Cold War era? To date, studies have focused largely on the mechanics of deployment support and the resourcing implications rather than the organisational aspects and how this might be developed to enhance mobility and reduce the forward support requirements, particularly the deployment footprint. I have always been an enthusiastic proponent of the semiautonomous maintenance organisation, believing the enhanced squadron *esprit de corps* brings very real benefits. But, this should not blind us to the very real issue of whether such a system is the best or indeed the only way to support deployed operations in the future. Is there not a very real danger that we are solving tomorrow's problems with today's solutions? At the very least the question should be debated.

Notes

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Lieutenant Colonel Todd J. Schollars, USAF

German Wonder Weapons: Degraded Production and Effectiveness

Introduction

World War II was the greatest conflagration this planet has ever known. It started as a few hegemonic nations annexing territory for economic reasons, then became an ideological battle between right and wrong, and finally ended in a battle of survival for Germany. Facing the Allies' unconditional surrender demands, the Germans combined fervent ideology, a powerful industrial base, and cutting-edge technology to produce weapons to stave off the Allied tide. The effort was mostly concentrated in developing air weapons, where Germany tried, and ultimately failed, to meet the dual and competing needs of strike and air defense. Germany developed several *wonder weapons* to overcome Allied quantitative superiority. Some of these weapons were obviously flights of fancy, while others served as the basis for many US and Soviet weapon systems in the Cold War. German wonder weapons were a cut above anything the Allies had, yet they were not able to change the tide of war because there were not enough of them on operational status. This fact generates two questions. First, why couldn't the Germans produce and deploy their advanced technology in any effective numbers? Second, if German wonder weapons had reached the front in quantity, would they have made a difference in the war's outcome?

The Wonder Weapons

Germany produced a large number of high-technology weapons during World War II. However, unlike the Allies' atomic bomb, electronic warfare, or Norden bombsight, the Germans were unable to reap benefits from their investment.

Germany produced a large number of high-technology weapons during World War II. However, unlike the Allies' atomic bomb, electronic warfare, or Norden bombsight, the Germans were unable to reap benefits from their investment.

The Messerschmitt Me 262 is, along with the V1 and V2, the best known of Germany's wonder weapons. It could fly at more than 540 miles per hour (compared to the P-51's 437 miles per hour); had an operational ceiling of 37,000 feet; and packed a punch with its four heavy, fast-firing 30-millimeter MK 108 cannon concentrated in the nose.[1] It was so far advanced beyond other fighters that General Adolf Galland, commander of Luftwaffe fighters, declared on his first flight, "It felt as if an angel was pushing."[2] The technology behind this superb aircraft was the turbojet engine, which produced more power than piston engines and created less drag than a propeller. The amazing performance of the turbojets shocked Allied aircrews when they first saw the Me 262. It could easily outrun escort fighters, allowing Luftwaffe pilots to dictate the terms of combat. This was especially important for overcoming the Allies' quantitative advantage. Once they were in close, they could deliver devastating fire from their cannon and rocket armament; only a few hits could bring down a heavy bomber.[3] The Me 262 clearly made Allied air leaders nervous because it represented the potential for Germany to regain air superiority. However, the aircraft was not without problems.

The turbojets of the 1940s were still in their infant stage and required delicate care from pilots and maintenance personnel alike. Any sudden throttle movements could cause an engine flameout, resulting in deceleration and a lengthy engine restart—not ideal when a pilot was in combat. The high speeds made formation flying difficult, complicating the concentrated attacks essential to breaking up bomber formations.[4] Both these limitations required highly experienced pilots, something Germany would find in short supply late in the war. Additionally, maintaining the Junkers Jumo 004 engine was time-consuming and needed considerable skill, also in short supply. Each engine had a life of about 15 to 25 hours before needing replacement,[5] creating both maintenance and logistics supply headaches. Rarely did an Me 262 geschwader (wing with 60 to 90 aircraft) have more than 16 serviceable aircraft for a mission.[6] Even with these problems, the Me 262 was still a potential *war winner,* if not for production and operational obstacles.

Germany was an early pioneer of air-to-air and air-to-ground rockets and missiles. One of the simplest, yet most effective was the R4M unguided rocket. The Me 262 could carry 24 of these small, simple, easy-to-produce weapons. Their size belied their strength: fired from outside the range of American .50 caliber defensive guns, one R4M had "indescribable efficiency—firing a salvo would hit several bombers—one rocket would kill them."[7] The attacks had the added benefit of breaking up bomber formations, making them more vulnerable to other Luftwaffe fighters. R4Ms also had the same ballistic characteristics as the MK 108 cannon, meaning the Me 262 could use the same sight for both weapons.[8] A more advanced weapon was the X-4, a fin-stabilized, liquid propellant, air-to-air missile, having a speed of 600 miles per hour and a range of 3.7 miles. After firing it from an Me 262 or Focke-Wulf Fw 190, the pilot would guide it to the bomber target via a wire connecting the missile and launching aircraft. Then the missile would detonate on impact or with an acoustic fuze.[9] The guidance system had the major disadvantage that the pilot could not maneuver his airplane while guiding the X-4, a serious problem considering Allied escort fighters. Germany was developing an acoustically guided version, using a type of sonar to reach the target and explode, but the war ended before it was ready. Had the Germans deployed the R4M or X-4 in significant numbers, it could have dented the Allied bomber offensive. Moreover, since the Luftwaffe was primarily a striking force, German scientists did not confine themselves to air-to-air missiles.

The Germans also used rockets to propel their fighters.

Germany developed two air-to-ground guided weapons during World War II, both used primarily to stem the tide of Allied shipping crossing the Atlantic Ocean. The first was the Henschel Hs 293—a 1,100-pound bomb with 10-foot wings, a tail, and a liquid rocket engine. The launching aircraft would fire the Hs 293 from outside the target ship's antiaircraft range (possible with the bomb's rocket), then remote control it via radio during its terminal glide to impact. The Hs 293 only impacted at 450 miles per hour, so it had less penetrating power than conventional bombs and was effective only against merchant ships.[10] The Germans overcame the penetration problem with the Fritz X guided bomb. This weapon did not have any propulsion. Rather, the aircraft dropped it as a normal bomb, then the bombardier guided its steep descent by radio remote control.[11] Both the Fritz X and Hs 293 had spectacular success, but Allied defenses overcame these weapons because of limitations cited later. Interestingly, the primary carrier of both weapons was the Heinkel He 177, a bomber whose serviceability greatly limited the bombs' employment, indicating Germany's integration problems.

The Germans also used rockets to propel their fighters. Two specific rocket fighters stand out as examples of what Germany was first able to design, then what shortages drove them to implement. First, the Me 163 was a high-performance interceptor. It relied on its flying wing design and single Walter R II-203 rocket engine to produce astonishing performance. It could reach more than 620 miles per hour and climb to 20,000 feet in a little more than 2 minutes. Allied fighters could not touch it, and it presented bomber gunners with a near impossible leading aim calculation. Like the Me 262, however, its propulsion system was not perfect. The fuels were hard to manufacture, extremely corrosive, and would explode if not properly mixed.[12] Further, two of the fuel tanks were beside the cockpit; any vapor or liquid leaks were life-threatening to the single pilot. The rocket burned more than 18 pounds of fuel per second, giving it not much more than 100 seconds of total burn time before the Me 163 became a vulnerable glider. Therefore, while it was a good basic design, lack of further development made the Me 163 operationally ineffective.

The second German rocket fighter was driven purely by economic and pilot shortages. The Bachem (Ba) 349 Natter launched vertically, climbed at more than 15,000 feet per minute, then flew at 600 miles per hour into the Allied formations, where it released its noseful of unguided rockets. Once its fuel was spent, the Natter glided back to base where the pilot ejected himself and the rocket engine—both then parachuted to earth.[13] The reason for this event was threefold. First, the aircraft structure was cheap and made of noncritical materials, so it could be disposed of. Second, the rocket was difficult to manufacture, so it needed to be saved. German engineers also knew that the shock of landing was likely to detonate any residual fuel, with dire results for the engine and pilot. Finally, the Natter was designed for inexperienced aviators. Since the vertical takeoff required no skills and landings were not attempted, pilot training could concentrate on intercepting the enemy.[14] This was clearly an extreme circumstance brought on by Germany's desperate situation late in the war.

The final wonder weapons of note were the V1 and V2 rockets, likely the best known of any German weapons. The V1 or Vergeltungswaffe (vengeance weapon) 1 was the world's first cruise missile. It employed a novel pulse jet engine (which made a distinctive sound, hence the name buzz bomb) and short wings to carry its 1,874-pound warhead to targets up to 150 miles.[15] While the overall idea was advanced, the V1 was actually unguided and flew a straight course until its primitive range-setting device locked the controls and crashed the missile into whatever was below, detonating the V1's warhead. This obviously was not a precision-strike weapon, but it did kill 6,184 people in and around London. This is still a record number of cruise missile deaths, impressive considering the number the United States has launched in the last 13 years.[16] The V2 was a prewar project designed to attack targets beyond the range of artillery. It was an unguided ballistic missile and the forerunner of today's intercontinental ballistic missiles and tactical ballistic missiles (the Scud is a direct descendent). The 28,500-pound missile lifted its 2,200-pound warhead[17] in a ballistic trajectory, then plummeted to earth at more than 2,200 miles per hour.[18] V2s were unstoppable after launch; the only way to halt them was bombing the factories or launch sites. V2s inflicted 2,754 deaths in London, Amsterdam, and Antwerp, a record that stood until the immense Scud exchanges of the Iran-Iraq wars.[19] The V1 and V2 were the only mass-produced and employed wonder weapons. As we will see later, there were several reasons why they were not able to produce the effects Germany needed to turn the tide of war.

It is evident the Germans developed air weapons without equal. However, their failure to mass-produce and deploy these weapons is a monument to *what could have been*. It is important to remember that while the air effort received the most attention, the Germans also developed land and submarine wonder weapons, all theoretically capable of providing the push Germany needed to overcome the Allies.

Production Problems: Why Germany Could Not Deploy the Wonder Weapons

Germany arose from the ashes of Versailles to become a huge economic power. Its industry, technology, and mass-production capacity led Europe and most of the world in the 1930s. So why could Germany not produce its wonder weapons in significant numbers? The problem was not capability. Rather, it was the restrictions and obstacles Germany placed on its industry that affected the production time line of extremely sensitive weapons. Four reasons behind Germany's lack of production are discussed here: political and military interference; the difficulty of mass producing advanced weapons; a lack of strategic vision; and finally, damage and dispersion resulting from the Allies' Combined Bomber Offensive. Any one of the reasons was enough to hamper generating high-technology arms; all four in concert were absolutely crippling.

The final wonder weapons of note were the V1 and V2 rockets, likely the best known of any German weapons.

Political interference was a great obstacle to producing weapon systems and was particularly fatal to advanced systems that required long development times. The political obstruction started early and at the top of the Nazi hierarchy. On 11 February 1940, Hitler canceled all development work that could not get aircraft to the front within 1 year.[20] Work stopped on a half dozen major projects, from jets to long-range bombers, all of which would have made the Luftwaffe more capable of fighting a lengthy war. When Germany became desperate for advanced weapons, its hurried response would produce aircraft that had not benefited from full development processes. So confident in early victory were Germany's leaders that they cut the legs out from under the Luftwaffe before the major war really started, denying it any chance of victory in a drawn-out conflict.

High-level conflicts marked the Nazi regime, as Hitler dueled with his advisors for control of the German military's strategic direction. Hitler cut through many of these disagreements by removing dissenters and consolidating power to himself. For example, he already had taken command of military operations when he took control of critical production programs. Although Hitler had a weak technical knowledge of aviation,[21] he realized the importance of jet engines and personally controlled jet engine allocation after June 1944.[22] His tight control took allocation away from production experts. The result was haphazard distribution to manufacturers and operational units, with a corresponding drop in production and aircraft in-service rates. Compounding Hitler's central control was his top officials' fear of or refusal to confront him on decisions they knew were wrong. At best, dissenters received Hitler's extreme verbal abuse, at worst, removal from office. By 1943, Hitler distrusted the Luftwaffe, and there were many cases of Hermann Goering's passively watching Hitler sow the seeds of his air force's destruction.[23] Even the outspoken Erhard Milch, chief of Luftwaffe production, took orders without objection. When Hitler *uncanceled* the Me 209 program in August 1943, Milch said, "But I have my orders. I am a soldier and must obey them."[24] He knew the restart would split Messerschmitt's production between an obsolescent fighter that would never see operational service (the 209) and a potential war winner (the 262). The best and most damaging example of this phenomenon is seen in the saga to produce the Me 262.

The Me 262 jet started development as a fighter and had capabilities far beyond contemporary piston engine aircraft. It was the top priority for production after Galland's first flight and subsequent endorsement. Milch canceled the Me 209 program to devote full attention to the new jet. However, Hitler interfered and restarted Me 209 production, largely out of fear of another failed advanced aircraft (such as the He 177) and its associated risk. There were already several problems with getting the Me 262 into production. Milch knew Hitler's decision to continue the Me 209 would take up space on Messerschmitt's assembly lines and delay operational employment of the Me 262 but went along, happy the Me 262 was still a fighter.[25] Unfortunately, Hitler's interference in the program had only started.

Political interference was a great obstacle to producing weapon systems and was particularly fatal to advanced systems that required long development times.

Hitler observed Me 262 demonstrations in December 1943 with several staff members, including Goering, Milch, and Galland. After seeing the Me 262, Hitler remarked, "I see the Blitz bomber at last! Of course, none of you thought of that!" Galland, referring to the plane's obvious fighter characteristics, remarked in his autobiography, "Of course, none of us had."[26] Milch actually went behind Hitler's back and continued developing the Me 262 as a fighter. When Hitler found out and confronted him at a meeting on 24 May 1944, Milch responded that the plane required extensive modifications and delays to become a bomber. Hitler exploded. "You don't need any guns. The plane is so fast it doesn't need any armorplate either. You can take it all out!" He then turned to the Luftwaffe's director of research, who responded that Messerschmitt could make the modifications without difficulty (actually, removing the guns and armor to make way for bombs would have changed the center of gravity so much Messerschmitt would have had to move the wings). Goering and Galland were so browbeaten, they remained silent, but Milch finally had enough, saying, "Even an infant could see it was a fighter."[27] Hitler fired him 2 weeks later. Thus, Hitler's meddling and his highest advisors' ineffectiveness at objecting caused significant delays in a potential war-winning aircraft and led to the dismissal of his best aircraft production coordinator. The Me 262 would eventually become a fighter but too late to be produced in numbers sufficient to wrest air superiority from the Allies. There were other systemic problems with producing the jet fighter, but Hitler's interference made it impossible for Messerschmitt to stick with a firm production schedule. This was only one of several obstacles that kept the wonder weapons out of the air.

High-level interference and bickering were not the only impediments to production. The Luftwaffe's officers contributed as well. Galland remembers rival fanatical groups within the officer corps, some more dedicated to Nazi idealism than actually producing an effective air force. This led to a crisis of trust and leadership, two elements on which depends the fighting strength of any unit.[28] Its result was no single voice speaking for the operational and strategic needs of the Luftwaffe; it also made it difficult for the Luftwaffe to present a united front to deflect high-level interference in weapons programs. Furthermore, we often remember the Luftwaffe as an honorable band of eagles. However, several pilots accepted checks from aircraft companies to endorse their products—planes that were often inferior.[29] This, combined with Goering's financial interest in several aviation factories, meant Germany based production choices on personal profit, rather than capabilities. Making inferior planes not only put the Luftwaffe further behind but also took assembly line space away from advanced projects. Military interference also played on a grander scale before the war even started by creating a war industry that could not meet the demands of mass production.

Germany's advanced technology production problems lay both in the character of the industry and pervasive military interference from project inception through delivery. First, German industry was craftsman-based to deliver very complicated weapons.[30] This was ideal for creating wonder weapons but made it nearly impossible to mass-produce them. Second, the armaments industry spread its capacity over several different specialized designs. Instead of a core of proven aircraft, German industry had 425 types,[31] once again hindering mass production and limiting the number of advanced aircraft produced. The reason behind this structure was military fastidiousness—the Wehrmacht liked working with specialized craftsmen because they could respond to the field's demands for weapon changes.[32] These changes did make the weapons more effective, but the constantly changing specifications made mass production impossible. No engineers or industrialists were consulted before making changes,[33] creating inefficiencies that further limited production. Finally, the Luftwaffe's first transformation came during the 1930s, when it could upgrade its equipment in peacetime. Conversely, the Allies had to transform early in the war; then stuck with late 1930s technology pushed to its limits, a huge production capacity overcame any qualitative shortfalls. However, Germany tried to transform to wonder weapons late in the war. Transitioning to a superior model in war actually can cause substandard combat readiness and degraded logistics as operators and maintainers learn to deal with new technology.[34] The result was German industry produced too little, too late, and actually decreased the Luftwaffe's capability.

Political obstacles, military interference, and an industry ill-equipped to make advanced weapons combined to hinder the wonder weapons' deployment. The cause of these problems was a complete lack of strategic vision, which prevented effective campaign planning and long-term weapons production. The lack of vision began at the highest levels and set a tone of short-range thinking that permeated the Luftwaffe, ultimately crippling its ability to prosecute any kind of strategic warfare. Goering was an extremely able fighter pilot. During World War I, he took command of Manfred von Richthofen's Jasta when the *Red Baron* died in action. However, Goering never gained the technical and logistical perspective needed to command an entire air force.[35] Before the war, he abandoned the 10-year prewar plan for a well-staffed and exercised strategic air force in order to attain short-term goals quickly.[36] The discarded plan included high-tech weapons, long-range strike aircraft, and the ability to put the German economy on a war basis before hostilities began. Even in early 1941, Goering could have pursued an aggressive program to increase German production but failed to do so. Luftwaffe military leaders also were more interested in active operations than preparing for the long term, because they desired tactical superiority at the expense of strategic readiness. This resulted from the massive catchup game Luftwaffe personnel played between the wars and made the officers technocrats and operations experts with limited vision. They could not relate airpower to national strategy, and the resulting defects were fatal.[37] When losses outstripped production in 1942, the Luftwaffe finally demanded construction increases. By the time the numbers caught up, there were not enough aircrews to fly them.[38] The only vision Germany had was a fanatical desire for a technological breakthrough to turn the tide of war,[39] relying on a belief in German superiority rather than reasoned strategic planning. Their fanatical desires not only diverted resources from realistic weapons programs but also gave the Allies targets for the Combined Bomber Offensive—the final impediment to German wonder weapons production.

Any discussion of German weapons manufacturing difficulties is incomplete without considering the Allied bombing campaign. Basically, the Combined Bomber Offensive made an already bad situation untenable for manufacturing wonder weapons.

Any discussion of German weapons manufacturing difficulties is incomplete without considering the Allied bombing campaign. Basically, the Combined Bomber Offensive made an already bad situation untenable for manufacturing wonder weapons. The reader must understand the Combined Bomber Offensive did not stop aircraft production—in fact, more aircraft rolled off the lines in 1944 (39,807) than in any previous year (15,904 in 1942, 24,807 in 1943).[40] However, it caused many operational problems for the Luftwaffe, as we will see in the next section. The Combined Bomber Offensive did cause two major problems with production, negating the impact of increased numbers. First, the bombing forced German industry to disperse, a measure contradictory to mass production.[41] Unlike America's huge aircraft plants like Willow Run, Germany had small factories in many places. While this made Allied targeting more difficult, it also hindered component integration. Different manufacturers also used different tolerances, meaning parts often did not fit together when assembled in the field.[42] Second, as soon as the Allies saw German wonder weapons in action, they were quick to find and strike the factories. After seeing Me 262s successfully attack a US bomber formation at 100 to 1 odds, General James H. Doolittle told Air Marshal Arthur Tedder, "Something must be done, and done quickly."[43] The result was dedicated, systematic attacks on wonder weapon facilities. It is very difficult to mass-produce sensitive, technically advanced weapons with dispersed industry subject to intense bombing. Increased Allied pressure also caused heavy operational losses with which replacements could not keep pace. This attrition was the final explanation for why the Germans could not produce their wonder weapons in significant quantities and turn the war in their favor.

Operational Difficulties: Would the Wonder Weapons Have Made a Difference?

This article has shown the obstacles Germany faced that made wonder weapon mass production and deployment nearly impossible. Even so, it did get limited numbers of its advanced hardware into service. This section will examine whether or not additional weapons would have attained Germany's goals. We must consider both the equipment and other factors such as available crews, training, and the operational constraints imposed by the Luftwaffe's ineptitude and the Allies' air superiority actions.

The first questions we must ask are, were the wonder weapons really that advanced, and if so, were they practical? In many individual cases they were advanced beyond the Allies' equipment, but they were incomplete packages lacking systems integration to other technology. For example, the Me 262 had the devastating 30-millimeter cannon. However, it never reached its full potential because the world's best optics industry could not design a good gyro gunsight that would fit in the jet.[44] A few experienced pilots learned to overcome the deficiency, but increasing numbers of rookies could not, leading to poor combat performance of an otherwise devastating weapon system. Further, the advanced Me 163 quickly ran short of fuel, then glided back to base. Similarly, the Me 262 flew slowly in the landing pattern, and its sensitive jets precluded any sudden power increases. US fighter pilots knew this and, thus, overcame the rocket and jet menace by orbiting their airfields, waiting to bounce the vulnerable fighters returning to base. This, in turn, forced the Germans to use Fw 190Ds for combat air patrols over their fields,[45] further exacerbating the fuel shortage. The air-to-ground weapons likewise had their faults. After releasing the Fritz X or Hs 293, the bomber had to fly a predictable course at only 165 miles per hour until bomb impact,[46] making the lightly armed bombers easy prey for naval fighters. Therefore, while the German wonder weapons were sophisticated, the failure to integrate them into total weapon systems presented vulnerabilities easy for the Allies to exploit.

The advanced technology also presented maintenance headaches for Luftwaffe ground crews.

The advanced technology also presented maintenance headaches for Luftwaffe ground crews. The previous section showed how production problems led to limited spares fabrication and parts incompatibility. Additionally, the emphasis on producing great numbers of new aircraft meant manufacturers were unwilling to *waste* production line space on spare parts, including jet engines.[47] The result was lower in-service rates for aircraft, because without spare parts, damaged aircraft were not repaired. Instead, ground crews cannibalized what they needed to keep other planes in service.[48] Cannibalism invariably led to fewer and fewer operational aircraft. The following story shows the effect of these maintenance troubles. Galland visited JG-7 (Kommando Nowotny) to see the Me 262 in action. The wing's leader, 250-kill ace Major Walter Nowotny, wanted a maximum effort to show why the Luftwaffe needed more Me 262s. This maximum effort consisted of 4 planes out of a unit of 80 aircraft; 2 of the 4 subsequently broke before takeoff. US pilots, having overwhelming numbers, then shot down one of the two remaining aircraft when Nowotny's engines malfunctioned during the dogfight.[49] Germany thus had lost one of its best fighter leaders, who was flying the best aircraft of his career but was let down by a system that could not integrate and maintain it.

Resource shortages forced Germany to use lower technology to gain increased performance. Fuel scarcity led Messerschmitt to experiment with simple steam turbine engines that used 65 percent coal and 35 percent petrol to deliver 6,000 horsepower.[50] They used the Me 264 long-range bomber as a test bed but were not able to produce and integrate the efficient engines before the war ended. Junkers also developed the long-range Ju 390 and worked on a refueling version to take Ju 290 bombers across the Atlantic. Even if the rumored Ju 390 flight to within 12 miles of New York is true,[51] this wonder weapon still could not hit America where it hurt—the industrial areas of the upper midwest. The same would hold true had the airplane used the coal and petrol engines. Similarly, the He 162 jet fighter was another step back: its wooden construction used noncritical materials and unskilled labor.[52] Hitler Youth were the intended pilots, problematic considering the plane's tricky handling. Hitler considered the aircraft and pilots expendable to stop the Combined Bomber Offensive. Fortunately for the young crews, they never flew in combat. While these wonder weapons allowed Germany to concentrate more materiel and fuel on other projects, they contributed no real capabilities to the Luftwaffe.

The most salient reason the wonder weapons would not have given Germany any advantage was the decreasing skill and experience of Luftwaffe pilots by the time the advanced systems arrived. There were two main reasons for waning crew proficiency. First, many of the best pilots had been killed in action or rendered unfit for duty. Operational losses meant there were few *experten* left in service. In fall 1944 alone, the Luftwaffe lost 12 pilots with 1,146 kills among them.[53] This not only decreased Germany's combat capability but also meant there were few *old hands* left to pass on hard-won knowledge to the new pilots. Most had been flying since 1939-1940 (some even had Spanish Civil War experience), giving them unmatched combat experience. However, the lengthy combat time placed a tremendous physical and psychological stress on them. Indeed, Galland noticed the lack of fighting spirit, even in 1943, when he saw several fighters fire on bombers from too far away to be effective, then leave for home.[54] However, there were some pilots ready to fight, and the limited wonder weapons gave them the spirit to return to duty. When assembling his Me 262 wing, Jagdverband 44, Galland rounded up the most raffish, battle-hardened veterans, several from the pilots rest home. "Many reported without consent or transfer orders. Most had been in action since the first day of the war, and all had been wounded. The Knights Cross, so to speak, was the badge of our unit. Now after a long period of technical and numerical inferiority, they wanted once more to experience the feeling of air superiority. For this, they were ready once more to chance sacrificing their lives."[55] Unfortunately for them, there were far too few pilots and even fewer superior weapons, those being not advanced enough to matter. Germany had again failed those who served her so well.

The second reason for the decreasing pilot skill was the poor state of the replacement program. Starting early in the war, the Luftwaffe's faith in early victory kept it from increasing the front-line force, so there was no pressure to raise training output.[56] When heavy losses set in, there was no reserve from which the Luftwaffe could draw. Later, when it realized it needed replacements quickly, the Luftwaffe lowered training time to only 112 hours, with 84 percent of the time spent in basic aircraft instead of high-performance combat types.[57] This was half the time Allied pilots received. The Luftwaffe also converted bomber crews to fighters, but the 20 hours' training they received was not enough to prepare them for the rigors of outnumbered fighter combat. Hitler even ordered all fighter groups on the Eastern Front to send two of their best pilots to the Reich's defense forces,[58] making the German lack of air superiority in Russia even worse. Finally, the Combined Bomber Offensive created a fuel shortage, leading to training curtailment as early as 1942.[59] Lack of fuel decreased instruction flights, further reducing new pilot skill and experience. All the above meant pilots arriving at the front were not skilled enough to handle basic aircraft, much less employ the highly sensitive wonder weapons (Galland relates how even his veteran pilots had trouble lining up for kill shots in the very fast Me 262).[60] This happened at the time Allied pilots were becoming more numerous and better trained as a result of combat veterans rotating home to instruct new pilots. Allied pilots also were becoming more experienced because of lower combat losses and were flying more aircraft of the same caliber as most German fighters. As the Luftwaffe's losses mounted, it closed the advanced schools, then the basic schools, moving the pilots and aircraft to operational units.[61] Replacements stopped just when the wonder weapons were arriving in numbers. Therefore, even with larger numbers of advanced aircraft, the Luftwaffe did not have the crews to fly them, negating their potential effect on the war's outcome.

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Several operational reasons kept the wonder weapons, even in greater numbers, from changing the course of the war. Most of these explanations arose from Allied air superiority and the Combined Bomber Offensive's incessant attacks on German industry and transportation. The struggle for air superiority in 1944 made the Luftwaffe commit 82 percent of its manpower and aircraft to defending the Reich.[62] While this estimate seems high, it does reveal how Germany had to retain forces to protect itself. Further, several wonder weapons, such as the Me 163, were point defense weapons. They were effective defenders but were incapable of extending air superiority over Allied territory or protecting the German Army from Allied close air support and interdiction. Lack of air superiority also meant the Luftwaffe could not conduct offensive operations. This left Germany with no route to victory, as the Allies' goal of unconditional surrender meant Germany could not play a defensive waiting game. Last, defending Germany used many weapons that would have been useful for ground defense and offense. For example, the Luftwaffe employed 10,000 88-millimeter guns as antiaircraft artillery; these guns were also the most effective antitank cannons of the war. Moreover, 500,000 people manned the air defense system, depriving Germany of needed ground troops and factory workers.[63] Hence, wonder weapons in sufficient quantity would provide adequate defense but would not have enabled Germany to go on the offensive and push the Allies away from its borders. As it was, Allied close air support and interdiction left Germany no avenue to overcome the numerical superiority of US and British ground forces.

Allied interdiction and the ground offensive also kept the wonder weapons from making a meaningful contribution. Allied armies overran many of the Luftwaffe's front-line airfields after the D-day invasion, forcing the Germans farther to the rear. Their subsequent operations from unprepared fields caused lower serviceability, so the Luftwaffe could not meet Allied quantitative superiority with higher intensity operations.[64] Relatedly, Ultra intelligence revealed German movement plans and allowed the Allies to attack Luftwaffe ground units en route to their new airbases.[65] This prevented supplies, parts, and mechanics from arriving to service their airplanes. Finally, the Allies' dedicated attacks on German transportation, especially the railroads, kept new aircraft components from reaching their assembly points (necessary because of the dispersed factories discussed previously). They also destroyed completed aircraft before they could reach combat units.[66] The wonder weapons were no exception—the Allies knew their value and were intent on killing the airplanes on the ground instead of facing them in the air. Consequently, wonder weapons in greater numbers would not have had the chance to become operational. If they had, they would be starved for gas; lacking pilots; operating from bases with no ground support; and thus, incapable of making a difference.

The struggle for air superiority in 1944 made the Luftwaffe commit 82 percent of its manpower and aircraft to defending the Reich.

History shows that superior aircraft did reach operational units. However, there were employment problems that would have increased had Germany deployed more of the advanced aircraft. First, Hitler was overtly hostile to any defensive measures. This, combined with his control of advanced production, meant fighter and antiaircraft deployments were piecemeal. Hitler believed a more effective defense was to meet terror with terror, causing him to deploy his new weapons in less than optimal ways.[67] Once airborne, the defenders did have the benefit of aircraft acting as airborne command posts to coordinate attacks.[68] However, it was only a local measure and did not affect the overall defense of Germany because it could not provide theater-wide situational awareness. Galland sums it up best: "We not only battled against technical, tactical, and supply difficulties, we also lacked a clear picture of the air situation, of the floods coming from the west—absolutely necessary for the success of an operation."[69] More wonder weapons inefficiently employed would not have improved the situation. They likely would have caused more confusion for the limited C2 system coordinating attacks on the bomber forces.

The final reason for the ineffectiveness of the wonder weapons comes from their secretive development and combat employment. Except for Goering and Milch, the Luftwaffe did not know about the Me 262's development until it was already in advanced testing.[70] There was no way for the units to develop training or tactics for the new aircraft if the operators did not know the planes were coming. Often a pilot's first experience with the aircraft would be in combat, with less than optimal results. Additionally, when Galland set up his JV-44 jet fighter unit, it was not subordinate to anyone—many felt it had finally shaken the micromanagement that had ruined the program. However, Hitler would not allow JV-44 to have contact with other units, fearing their defensive mindset would contaminate strike units.[71] This isolation was an effective quarantine, meaning the best pilots could not share their skill and experience with other units, especially those trying to employ complex equipment with rookie crews. The new pilots then had little chance to improve except in one-sided combats with Allied fighters. Lack of tactics for the advanced aircraft and the moratorium on sharing expertise would have made more wonder weapons just as ineffective and would have given the Allied fighter pilots easier targets.

The Luftwaffe was unable to prove what it could have done with more wonder weapons, as production difficulties kept it from reaching the operational numbers that could have made a difference. Incompletely integrated technology, decreasing crew skill and experience, a deficient training program, and Allied attacks kept the advanced aircraft in service from effective operations. These problems would have handicapped greater numbers as well. Galland's comment at the war's end concludes it well. When his unit finally received Me 262s, he said:

> But this was 1945! In the middle of our breakup, at the beginning of our collapse! It does not bear thinking what we could've done with jet fighters, 30-millimeter quick-firing cannons, and 50-millimeter rockets years ago, before our war potential had been smashed, before indescribable misery had come over the German people through the raids.[72]

Fortunately for the Allies, the wonder weapons did not arrive on the scene until it was too late to make their mark.

The V1 and V2 Case

So far, we have seen several reasons why the wonder weapons would not have made a difference, even if Germany had deployed them in significant numbers. However, there is a case showing two wonder weapons Germany managed to develop, produce, and use in large quantities: the V1 cruise missile and V2 ballistic missile. This section will further prove the point that greater numbers of advanced armaments would not have made a difference by demonstrating how 35,000 V1s[73] and 10,000 V2s[74] could not change the war's outcome. The primary reasons were the missiles' technology, the theory behind their combat employment, and production interference. It is logical to assume the other wonder weapons would experience similar problems had Germany mass-produced them.

The first topic is numbers. As we saw earlier, Germany built 35,000 V1s and fired 9,200 of them, killing 6,184 people in England.[75] Likewise, 1,300 V2s hit England between October 1944 and March 1945, killing more than 2,700 and wounding 19,000. V2s had some success degrading Allied logistics with attacks on Antwerp but, on the whole, were another futile effort to turn the war in Germany's favor. Why couldn't huge numbers of these weapons make a difference, especially considering the V2 was unstoppable?

No other countries developed cruise or ballistic missiles during World War II. In fact, the United States and Soviet Union used both the V1 and V2 to create their own systems after the war. However, closer examination reveals the missiles had several of the other wonder weapons' problems: relatively low technology, little systems integration, and minimal reliability. To start, Allied fighters could easily catch the slow (400 miles per hour) V1s and shoot them down. If they were out of ammunition, a few pilots dared to tip the V1s over by placing their wing under the V1's wing and then flicking it up, causing the missile to spin out of control.[76] The British set up dedicated warning nets to detect the incoming V1s and then sent out interceptors. Royal Air Force (RAF) action thus dispatched 4,000 of the 9,000 V1s fired.[77] Interestingly, the British kept all their new Meteor jet fighters in England to deal with the missile threat.[78] However, this was not a victory for the wonder weapons, as the Meteors did not have the range to escort bombers and were not ground attack aircraft either (the Allies already had plenty of aircraft to cover those missions). Vulnerability to interception was not the V1's only problem. A greater fault afflicted it and the V2: lack of accuracy.

While the English could not shoot down the V2s, they and the V1s that penetrated the defenses were extremely inaccurate: V1s had a 12-kilometer circular error of probable (CEP), while V2s had a 6-kilometer CEP,[79] meaning only half the rounds fired fell in a circle with the CEP's radius. The reason was neither *advanced* system had a guidance computer. The V1 flew straight at a constant speed (the engine actually lost efficiency as it burned, keeping the missile at the same speed even though it was getting lighter as it burned fuel),[80] then plunged to earth after the primitive air log propeller in its nose had counted the appropriate number of rotations. Once the air log reached the preset number, it locked the V1's controls so it would dive into whatever was below.[81] The Army's V2 was designed as long-range artillery[82] and essentially lobbed its warhead beyond gunfire's range. Considering the problems of ballistics, high-speed reentry, and rocket efficiency variations from poor fabrication, it was lucky any V2s hit their targets. Even a simple guidance system would have made the missiles more accurate and, certainly, more a threat to Allied targets. These limitations point to the fact that the V weapons were not that technologically advanced—an issue that reduced their effectiveness.

The V weapons caused relatively few deaths or damage, especially compared to the Combined Bomber Offensive.

The V weapons caused relatively few deaths or damage, especially compared to the Combined Bomber Offensive. Three reasons caused the lack of destruction. First, the horrendous accuracy made pinpoint attacks impossible. The Germans did develop a missile-mounted transmitter that stopped signaling when the V1 hit the ground, allowing corrections for the next shot.[83] The ever-resourceful British electronic-warfare teams countered this tactic, spoofing the signal to make the weapons miss by even more.[84] Second, both missiles had very short range: the V1 required launch sites in Holland, with the V2s not much farther back. Even that close to England, the missiles could not reach the heavy industrial areas. Once the Allies liberated Holland, then the rest of Western Europe, the missiles had no way to reach their targets. The only exception was He 111-launched V1s (the first air-launched cruise missiles), which were impractical because of Allied air superiority.[85] Third, the Allies knew well the capabilities of the V1 and V2, capabilities that would increase if Germany could improve the missiles' guidance. The RAF and the US Army Air Forces also knew where the Germans built and launched the weapons and subjected the installations to unrelenting attack. Once again, the Combined Bomber Offensive created a final obstacle for wonder weapons and made a system that was not making a difference completely useless. With their inherent problems, why then did Germany focus so many resources on building and launching the V weapons? The answer lies in the unique political and military views of the Nazi party.

The lack of accuracy did not bother the Nazis, as the weapons' main purpose was terror, a goal that denied the Germans any chance of effectiveness. Hitler believed they were the *decisive weapons* that would bring him ultimate victory by destroying England and the Allies' will to fight.[86] Had Hitler looked at his own people, he would have seen the Combined Bomber Offensive's tremendous destruction had not broken their spirit,[87] even under daily attacks that dwarfed the entire V1 and V2 campaigns. In addition, he should have learned a lesson from the Battle of Britain, where his extreme efforts could not touch the English spirit. While the V weapons did cause psychological strain,[88] the V1 counter campaign actually had a solidifying effect on British morale. The population eagerly tracked the operation's progress, hailing each interceptor's kill, especially the *tippers.*[89] England had no counter for the V2, but the people soon realized the low threat from the inaccurate missile, seeing it could only strike populated areas. They had dealt with terror raids before, and with the war going the Allies' way, they saw the V2s for what they were: weapons that could terrorize but not effectively hurt the Allies. Therefore, Hitler's purpose for employing the V1 and V2 actually helped the Allies' cause. At the same time, the weapons hurt Germany's chances for developing other wonder weapons.

The V weapons programs impaired other advanced projects by consuming vast resources and manpower that Germany could have used to make effective armaments. When Hitler saw a V2 demonstration film on 7 July 1943, he directed that the program receive whatever labor and materials it needed. The program cost more than 5 billion reichsmarks and absorbed tens of thousands of workers (many of them slaves, an additional factor in the poor workmanship)—enough to have produced 24,000 aircraft.[90] The effort compromised the rest of Germany's war economy and prevented programs from having real strategic worth. One such weapon was the Hs-117 radio-controlled surface-to-air missile,[91] something the Germans needed to counter the Combined Bomber Offensive. The resource expenditure did not stop with the basic missile. Germany pursued two extreme measures to improve the weapons. First, it developed a manned V1 much like the Japanese Ohka kamikaze rocket plane. Unlike the Japanese, the Germans found few volunteers to man the aircraft, even after a test program led by famous pilot Hannah Reitsch.[92] One can predict the program would have improved accuracy but would have resulted in many deaths from Allied interception before the missiles reached their targets. The second scheme involved a Type XXI submarine (another wonder weapon) towing a V2 that rode in an underwater launch center to its liftoff point near the US east coast.[93] Although the designers knew it would have minimal accuracy, they justified the expenditure by saying the weapon's harassing effect would have strategic and political results. Germany produced one of these weapons in the 5 months preceding the war's end but never used it. These problems highlight Germany's complete lack of strategic vision and judgment of what made a successful weapon. The same problems would have affected the other wonder weapons had they reached mass production and deployment.

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The V weapons were the only wonder weapons that saw mass production and employment yet had insignificant effect on the war's outcome. The basic problems of integration, poor accuracy, futilely striking morale, and wrongly prioritized expenditures made these wonder weapons, at best, useless, and, at worst, a war loser for Germany. We can see the same problems affecting the other advanced projects as well, showing again what little effect they would have, even in large numbers. In the final analysis, the wonder weapons only promoted the fantasy of the next technological breakthrough that would change the war.[94] This fantasy was at the expense of practical weapons that could have given the Luftwaffe and Germany a real chance at victory.

Relevance for Today: The US Defense Transformation

Examining the past for historical interest is fine, but it has true value when one applies it to similar events happening today or that could happen in the near future. Adapting a common phrase, one can see that those who do not learn from the past are doomed to repeat it or, at least, will miss opportunities. World War II Germany attempted to transform its war effort with technology but did not have the strategic vision, operational integration, or production capacity to pull it off. One can easily draw a parallel between Germany's efforts and the current US transformation employment. This section will examine the ongoing US military transformation with respect to producing technology, integrating it with other innovations and current weapon systems, then using it to execute national security strategy in a challenging world. Additionally, it will compare German efforts to do the same, showing the pitfalls on the way toward dominance in all phases of warfare.

Producing high technology has been America's trademark since World War II. During the Cold War, the United States counted on quality to defeat the Warsaw Pact's quantity. Whereas the Germans canceled all programs that could not be completed within 1 year, Secretary of Defense Donald Rumsfeld wants to cancel all projects that do not take the military to the next level.[95] This is a result of the US strategic orientation toward the long term, rather than focusing on near-term issues. However, the Department of Defense (DoD) must avoid going to the other extreme, because putting all its hope in next-generation weapons will be to the detriment of current and proven technology. Two reasons support this point. First, advanced technology is very expensive, making it difficult to replace combat losses.[96] The Luftwaffe demonstrated this lesson, and the DoD would be wise to learn it. Second, wars are now *come as you are*, leaving little time to develop new weapons to meet current threats—it could be disastrous to get caught between technological advancements. The key for producing technology is how the United States spends money. Germany could not control its wonder weapons' escalating costs, and it skewed the entire war economy. If the DoD cannot control the exponential cost growth in next-generation weapons, it could price itself out of the defense business altogether. The United States needs to make astute decisions regarding successor weapon systems, in some cases making ruthless choices to ensure it spends money in the right places to produce effective forces within a reasonable time.[97] Producing technology is important; more crucial is how the military integrates that technology into operations.

Germany failed to integrate its world-leading technology into effective weapon systems, leading to arms that were not as effective as they could have been. Component shortcomings, lack of aircrews, and maintenance problems contributed as well. The current DoD transformation has a better focus. According to Rumsfeld, transformation is more than building high-tech weapons. It is about finding new ways of thinking and fighting. The goal is not to transform within 1 year or even 10 years—it is an ongoing process.[98] While DoD works the process, it cannot assume new is always better, because integration will always limit high technology[99] until all weapon components are at the same development level. Additionally, a smaller force of less sophisticated weapons leaves more money for maintenance and upgrades.[100] A good example of this is the recent reduction in the B-1 force, allowing the Air Force to upgrade the remaining bombers to be more effective against moving and time-critical targets. Relatedly, buying versatile weapons can bring down costs, improve integration, and increase effectiveness. The new push for an F/A-22 (vice an F-22) shows the Air Force is moving toward versatile platforms.[101] Integrating the technology is vital; equally crucial is taking care of the people who run the weapons. It would be a mistake for DoD to neglect training, retention, and services to pay for new weapons. Germany was unable to use its advanced aircraft for want of experienced aircrews. Current weapons are even more advanced and require the best people to make them effective when the military uses them.

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Developing, producing, and integrating technology does no good unless the United States uses its transformed power in an effective way. There are four ways it can employ power to make the fullest use of the transformation. First, the Services need clear concepts of operations (CONOPS) to guide both using the technology today and as a roadmap to the future.[102] Without thoroughly developed CONOPS describing how to employ new weapon systems to meet long-term goals, the DoD runs the risk of short-term thinking. The Air Force is pursuing eight CONOPS, covering everything from space to global strike and mobility, to realize its vision.[103] Second, the military must use a combination of old and new technology to get the job done. For example, Global Positioning System-guided munitions are superior high-accuracy weapons. However, they are much less effective without a man in the field using simple sighting equipment to find and pass target coordinates to orbiting aircraft. This supports the idea of not placing all hope in fantastic equipment. Third, while fighting the war on terror, the United States cannot become stuck in a defensive mindset like Germany did and lose its capability to strike its enemies. The Secretary of Defense and many other high-level government officials have stated the best defense against terror is a good offense,[104] an appropriate attitude that the United States has so far followed. Moreover, America should be realistic in planning to employ its power. The DoD has finally moved away from the two major wars scenario to a more realistic approach of fighting one major conflict while holding ground in other contingencies.[105] The DoD is doing this by replacing its Cold War threat-based approach with a capabilities-based view. This concept looks beyond current uncertain needs in order to maintain strategic flexibility and resistance to asymmetric surprise.[106] Thus, the capability-based approach directs readiness for the most likely military needs instead of preparing to counter threats that do not pose a realistic danger. Finally, the United States is strongly advocating effects-based operations (EBO).[107] These operations concentrate on achieving effects that will force the enemy to do our will, instead of just destroying targets that produce arbitrary effects. This requires the military to integrate all systems to find, target, and attack those centers of gravity that will make maintaining the status quo impossible for our adversaries. Attacks requiring pinpoint accuracy to eliminate collateral damage are tailormade for advanced technology, but the United States must ensure it is hitting the right things. Germany squandered its ballistic and cruise missiles trying to attack British morale and ultimately did not attain its goal. The same fate awaits the United States if it does not do its homework to find those things that truly hurt its enemies.

Developing technology while not becoming over reliant on it, integrating advanced weapons to get full use out of all systems, and using the systems most effectively will allow the United States to avoid Germany's problems. Building a transformation to keep America ahead lets it fight on its terms and keeps enemies off balance and struggling to catch up. The United States must be ready for asymmetric threats and let other countries fantasize about finding their own wonder weapons to change their fortunes. If the DoD transforms correctly, it will not only be ready for them but also may even deter adversaries from using counter technologies against America.

Nazi Germany possessed the technical prowess and industry to produce several wonder weapons during World War II. Its jet and rocket fighters, guided missiles, and cruise and ballistic missiles were all ahead of their time and superior to Allied armament. However, Germany could not transform its military into an effective force to stem the rising Allied tide for several reasons.

Conclusion

We now know the dominant weapons on the battlefield are the ones that can be mass-produced, operated by motivated fighters, kept in action with spares and supplies, and used in concert with other weapons.[108] Ignoring the above advice in pursuit of superior weaponry courts disaster. In the words of General George S. Patton, "How easily people can fool themselves into believing wars can be won by some wonderful invention rather than by hard-fighting and superior leadership."[109] Nazi Germany possessed the technical prowess and industry to produce several wonder weapons during World War II. Its jet and rocket fighters, guided missiles, and cruise and ballistic missiles were all ahead of their time and superior to Allied armament. However, Germany could not transform its military into an effective force to stem the rising Allied tide for several reasons.

Germany's first significant problem was producing and deploying its wonder weapons. Many times, Nazi politicians interfered in projects, creating obstacles to efficient production. Further, the military itself played too large a role in design and production specifications, with changing demands making any kind of mass production nearly impossible. Corruption also played a role in keeping incompetent designs afloat, taking valuable production capacity away from truly useful projects. All this boiled down to a lack of strategic vision rising from the Germans' overconfidence in quick victory, a problem that plagued both weapons production and military operations. Finally, the Combined Bomber Offensive made an already horrible system untenable and was the straw that broke Germany's wonder weapons capacity.

Weapons are no good if a country cannot use them. Had Germany actually mass-produced its wonder weapons, it is doubtful they would have done any good. First, the weapons were not that advanced as systems because of German industry's failure to integrate them into total packages. Second, long-term pilot losses led to decreasing crew experience. This, combined with an inadequate training system, meant there were insufficient pilots to fly the wonder weapons. The Luftwaffe compounded the problem late in the war when it completely stripped its training units, sending all pilots and planes to fight. Third, Germany's focus on defense left it little capability to conduct offensive operations to truly hurt the Allies. When it did attack with its only mass-produced wonder weapons, the V1 and V2, it sought only terror effects. Its targeting mistake made the V missiles even more ineffective than their inherent inaccuracy dictated. Additionally, the missile program diverted enormous resources from other projects that could have dented the Allies' progress. In the end, the blade that cut through Poland, France, and the rest of Europe could not be sharpened by the wonder weapons and was ultimately too brittle to survive the exhausting conflict.[110] It dulled against the Allies' steel and concrete and was shattered in its turn, ending any chance of German victory.

The lesson Germany failed to learn is relevant today, as the United States moves to transform its military. We must heed the lesson that it is not enough to produce high technology with a short-term strategy. Instead, the United States must make careful choices on what to develop in the budget-constrained economy and fully integrate new weapons with the support systems and people on which they depend. Then it must effectively and realistically employ its transformed military to keep adversaries off balance. Producing, integrating, and employing new wonder weapons to strike targets for effects rather than brute destruction will bend adversaries to US will and allow the United States to attain its national security objectives. Germany lost the opportunity to become and remain a truly advanced power. America is totally dominant in many factors but must continue its ongoing transformation process to stay ahead and provide unmatched military effectiveness.

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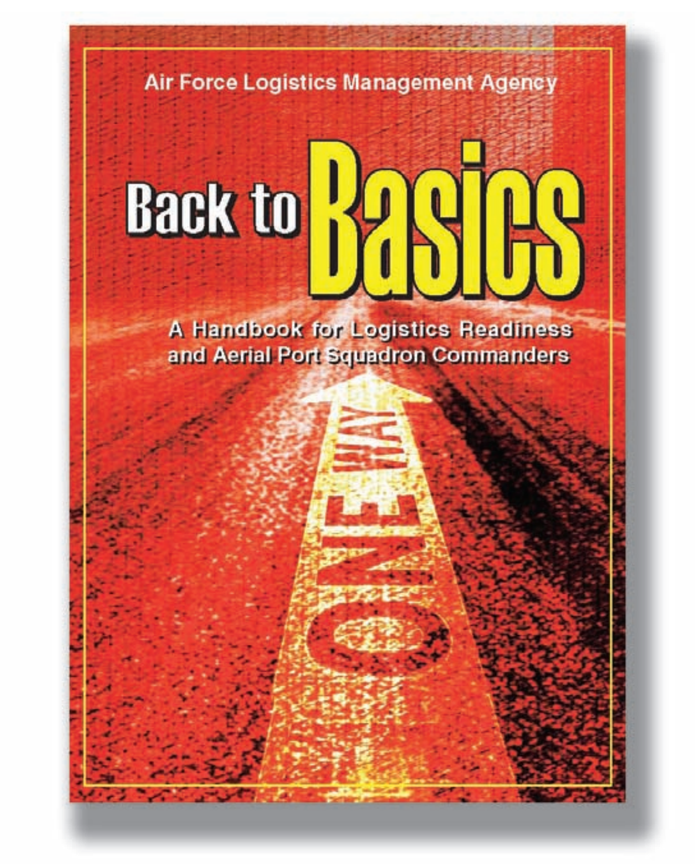

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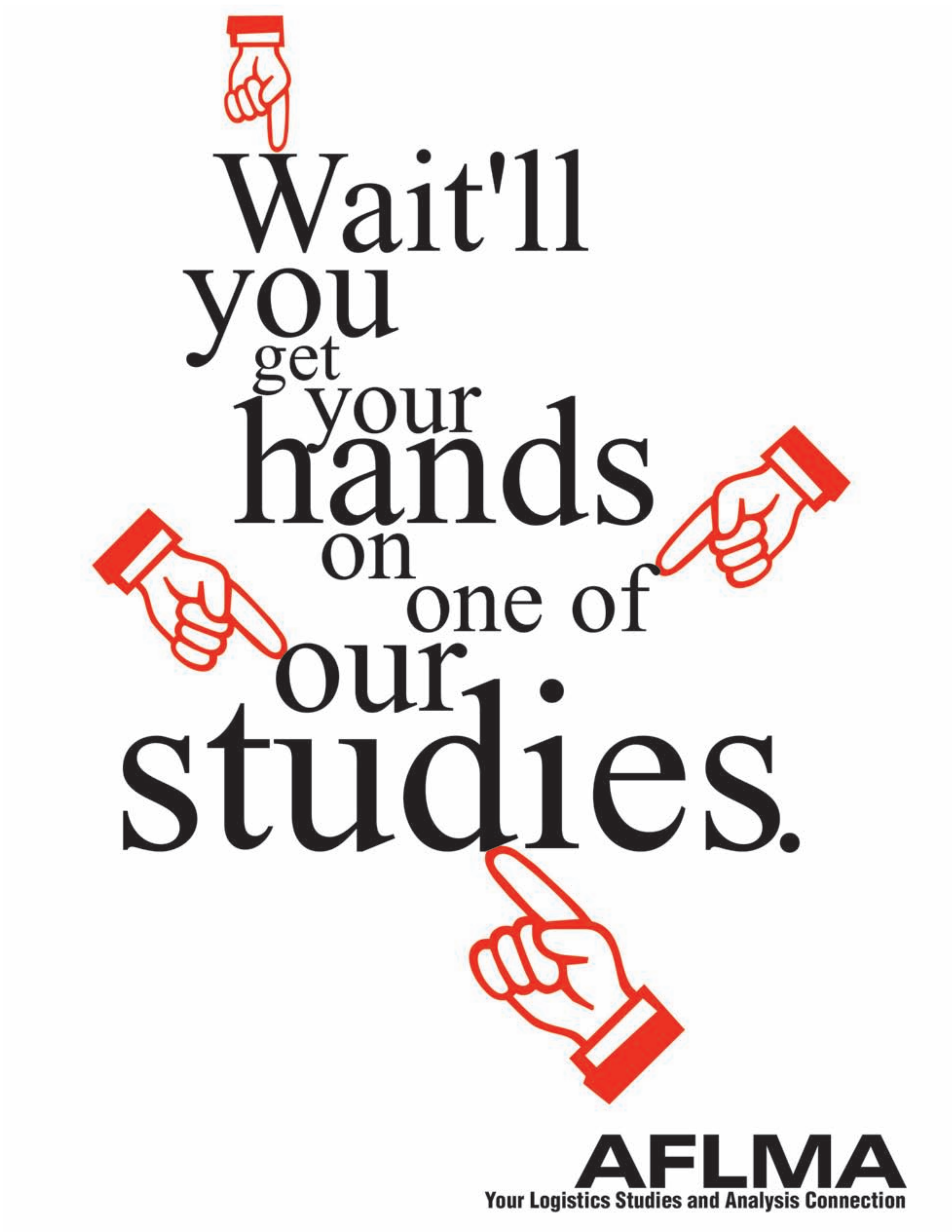

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A Historical Perspective on the Future of Military Logistics

The battle is fought and decided by the quartermasters before the shooting begins.[1]

—Field Marshall Erwin Rommel

No matter their nationality or specific service, military logisticians throughout history have understood the absolute truth represented in the above quote. Whether they were charged with supplying food for soldiers, fodder for horses or the sinews of modern war—petroleum, oil and lubricants (POL), they have understood that victory is impossible without them—even if, sometimes, it seemed their vital contributions were forgotten or ignored. None of the great military captains of history were ignorant of logistics. From Frederick the Great to Napoleon to Patton, they all understood the link between their operations and logistics. The great captains also have all understood that history had much to teach them about the nature of the military profession. Yet, military logisticians do not often spend time studying the history of military logistics.

This article is an attempt by one military logistician to derive relevant general lessons from history that might prove of some use in understanding how best to prepare for the future. There are at least three such general lessons. The first of these is the best case operationally is often the worst case logistically. The second is promises to eliminate friction and uncertainty have never come to fruition. And the third is technological change must be accompanied by organizational and intellectual change to take full advantage of new capabilities. While these lessons are not exclusive to logistics, when applied to the understanding and practice of military logistics, they provide a framework for understanding the past and planning for the future.

Such a framework is vital, now more than ever. Documents such as *Joint Vision 2010*[2] and the follow-on work supporting it are designed to set the course for the US military for the next 15-25 years. Logisticians must not only be proactive in helping set that course, they must use all resources available to ensure it is the right course. A thorough understanding of these three lessons will be of use in this regard.

The Lesson of the Best Case

The truth of the sentiment expressed by Field Marshall Rommel was no more apparent than on 2 September 1944 when General George S. Patton's Third Army ground to a halt from lack of fuel. The subsequent pause by Allied forces after their breathtaking race across France allowed the Germans to regroup and reconstitute their defenses and contributed to the extension of the war by another 8 months. Given the logistical riches of the Allies, one is forced to ask why they allowed this to happen. The answer is their failure to plan for the *best case*.

The historical record shows that September 1944 was not the only instance of logistical failure in spite of logistical riches. Logistics planning for *best case* possibilities is just as important as planning for the worst case in supporting military operations. In fact, the best case operationally is often the *worst case* logistically, and the following historical examples support this assertion.

The first historical example is provided by the German invasion of France through Belgium in 1914. The German troops marched farther and faster than the peacetime planners had calculated. Since other logistics calculations were predicated on the estimated rate of

The German troops marched farther and faster than the peacetime planners had calculated. Since other logistics calculations were predicated on the estimated rate of advance, they were also in error. As a result, the railheads could not be kept within supporting distance of the advancing armies, and heavy transport companies were totally inadequate.

advance, they were also in error. As a result, the railheads could not be kept within supporting distance of the advancing armies, and heavy transport companies were totally inadequate. The failure to plan for the operational best case—a quick breakthrough and advance—could have had a serious impact on the capabilities of the combat forces. In this particular case, it did not because the French halted the German advance before logistics difficulties could. Be that as it may, the evidence indicates the Germans would have had to halt due to logistics problems, and they got as far as they did only through *furious improvisation.*[3]

The second example of failure to plan for the best case is from the North African campaigns of World War II. Both Rommel and the Allies succeeded in putting their operational best case into motion, but ultimately failed because these proved to be the logistical worst case. On at least two occasions, Rommel's offensives achieved massive breakthroughs against the British in the east. He was, however, unable to translate these tactical successes into lasting operational or strategic success because he had completely outstripped his logistics system. Given the distances involved, the primitive transportation infrastructure, the lack of coastal transport capabilities, British air superiority and the lack of effort in correcting these deficiencies, his actions were logistically unsupportable.[4]

Allied efforts in the west after the landings of Operation TORCH were similarly hindered. The failure to effectively plan for the best case was even more egregious in this instance, however, since they were operating from a position of abundance rather than scarcity. The key objective after the landings was to occupy Tunis before the Germans. The best case operationally was no resistance from French forces and a lightning advance to the east. In order to support this logistically, the Allies would have had to reconstitute and augment the existing rail system and bring enough trucks to fully exploit the limited road network. Yet, they did not allocate enough resources to accomplish the task and support the advance. The number of vehicles transported with each convoy was successively reduced with each iteration of the plan. The focus was on the mere accumulation of supplies—to the point that by the time the plan was executed, the port capacity was approximately two and a half times the combined rail and road capacity.[5]

The actual worst case logistically resulted from the best case operationally. The advance far outstripped the schedule, and transportation capability became the limiting factor. By the time Patton had to halt, POL and ammunition stocks were increasing on a daily basis at the beaches and ports but could not be brought forward.

The third example of the best case planning error, and perhaps the most inexcusable from the standpoint of not having learned from experience, is the Allied advance across France. On 25 July 1944, the Allies were 44 days behind schedule. On 31 August, Patton was 150 miles and 5 months ahead of schedule. The 6,000 trucks of the *Red Ball Express* were using 300,000 gallons of gasoline daily to bring him the 350,000 gallons a day that he needed. By 2 September, he had to stop when the entire improvised system collapsed.[6]

Logistics planning for the breakout from the Normandy beachheads was based on the assumption of a slow, deliberate advance in the face of an orderly German withdrawal. The supply sequence entailed arrival at beach, port or harbor and then transport by rail and truck to supply dumps within tactical distance of the advancing forces. The worst case planning of the logisticians involved the possibility of higher consumption rates than projected. Consequently, the actions taken to preclude the worst case were focused on the accumulation of supplies. As noted above, the actual worst case logistically resulted from the best case operationally. The advance far outstripped the schedule, and transportation capability became the limiting factor. By the time Patton had to halt, POL and ammunition stocks were increasing on a daily basis at the beaches and ports but could not be brought forward.[7]

The lesson of these three examples can be summarized as follows. World War I marked a turning point for military logistics. Prior to this time, a moving army was easier to supply than a stationary one because food (for men and animals) was the critical element, and the means to obtain it was through foraging. After 1914, the moving army was much more difficult to supply because the critical element was ammunition (and subsequently, POL), for which foraging is not a viable option.[8] The logisticians learned this lesson almost too well. Their focus became the accumulation of supplies before the beginning of operations and their *worst case* became the point when consumption outstripped accumulation. These examples show, however, that accumulation is only half the equation; the other half is transportation. And in modern mobile warfare, the best case for the tactical forces, for example, the greatest rate of advance, is often the worst case for the logisticians supporting them because of limited transportation capability.

The Lesson of Friction and Uncertainty

The second historical lesson for logisticians involves the nature of friction and uncertainty. Throughout history, military planners have sought to reduce and even eliminate these two facts of life. The side that has made the greatest strides toward doing so, or at least made greater strides than its enemy, has also taken great strides towards winning. It has become increasingly tempting with our modern technologies to claim proximity to the *Holy Grail* of their actual elimination. *Joint Vision 2010* uses phrases such as *dominant battlespace awareness*, the *uninterrupted flow of information*, and *full dimensional protection*.[9] An even more insidious problem occurs when friction and uncertainty are assumed away without even a cursory reference. Logisticians must be aware of and avoid the pitfalls inherent in this approach.

In *On War*, Carl von Clausewitz first applied the concept of friction to the analysis of war. A series of quotes will serve to illustrate his meaning.

> Friction … is the force that makes the apparently easy so difficult … friction … is everywhere in contact with chance, and brings about effects that cannot be measured…. The good general must know friction in order to overcome it whenever possible, and **in order not to expect a standard of achievement in his operations which this very friction makes impossible**.[10] [emphasis added]

Friction, in other words, is a rather more elegant expression of Murphy's Law. Clausewitz was trying to tell us that military operations exist in the realm of Murphy's Law, and good commanders adjust their plans accordingly, rather than trying to eliminate it.

Logisticians are subject to the effects of friction and uncertainty almost every day, and yet, often forget their effects when planning—or, conversely, try to anticipate and plan around every possible contingency. The earlier discussion of *the best case-worst case* dichotomy serves to illustrate this point as well. Another example occurred during British operations against the Argentines in the Falklands. The ship *Atlantic Conveyor* was sunk by the Argentine Air Force before she was able to unload her cargo of helicopters, airfield construction equipment, and tents. The British plan was predicated on concluding operations as quickly as possible—primarily because of the long lines of communication and the weather. The cargo sunk with *Atlantic Conveyor* constituted a large part of their capability to do so. "Her loss, while removing the means to speed up the operation, made an early termination even more imperative."[11] One is forced to ask why all such vital cargo was loaded on one ship; apparently no one anticipated the effects of such a loss.

The converse *sin* of trying to eliminate friction by anticipating and planning for all possible contingencies can lead to such rigidity that an unanticipated event or last-minute change is completely disastrous. The most obvious example of such a circumstance is the German mobilization for World War I. German logisticians had planned their two-front war in impeccable detail—right down to the number of trains over each bridge in a given time. And when the Kaiser asked Von Moltke to fight only to the east, against the Russians, Von Moltke answered, "it cannot be done … if Your Majesty insists … [the army] will not be an army ready for battle but a disorganized mob … with no arrangements for supply. Those arrangements took a whole year of intricate labor to complete."[12]

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It is tempting to think that we would never do such things. It is tempting to think that it is a different age, that such rigidity is unnecessary now. It is tempting to think that Murphy's Law is *not as bad as it used to be* because we have such wonderful technology. It is tempting, but we would be wrong to draw such conclusions. Friction and uncertainty will remain with us because of three immutable factors.

First, human beings are still an integral part of the logistics system—and human beings make mistakes, and sometimes they act irrationally. They get bored and enter data into their computers incorrectly. They work for 4 or 5 days with minimum sleep and then fail to secure a load properly—and it falls off the truck and is lost. They feel the pressure of ongoing operations where mistakes can cost lives and make even more mistakes. Our friend Clausewitz pointed out that the military machine "is composed of individuals, every one of whom retains his potential of friction."[13]

The second reason that friction and uncertainty will remain with us is that the military is a complex system, in the scientific use of the term. According to Charles Perrow, complex systems are those systems with multiple interactions among parts, procedures and operators. These systems are subject to interactive failures because their designers and users cannot anticipate all the possible interactions and are, therefore, unable to predict all the possible outcomes of any given decision.[14] Such complexity produces surprise. Unforeseen outcomes result when minor variations lead to some unpredictable total. Organizations typically react to these unpredictable results by adding more complexity, thereby exacerbating the problem rather than solving it.[15] One needs only examine the examples discussed earlier, or the surprise achieved by the Japanese at Pearl Harbor, in light of this definition, to see how it holds true for military organizations.

The final reason military logisticians cannot escape friction and uncertainty is that the ultimate *consumer* of military logistics is an enemy who has a vested interest in ensuring the logistics system fails. Again, Clausewitz has captured the fundamental idea: "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."[16] The whole object of the logistics system is the same, and the *leaner* we make the system, the scarcer the resources become, the more dependent we are on critical information nodes, the more lucrative a target we have created. The *Atlantic Conveyor* is an example of such a target.

The Lesson of Change and Innovation

The third historical lesson for logisticians is organizational and intellectual change must accompany technological change in order to take full advantage of new capabilities. Innovations do not necessarily result from new technologies. New technologies may simply be used to do existing missions better. Innovations occur when new procedures are built around changes in the way organizations relate to each other and to the enemy.[17]

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Again, the best case-worst case dichotomy discussed previously is applicable. For example, the problems experienced by Allied logisticians in supporting the breakout and pursuit across France were as much a failure to adapt intellectually and organizationally as anything else. The planners had already experienced the logistical problems of North Africa, but failed to adapt.

The foundation of that failure to adapt was the failure to recognize that a change in operational concept warranted a change in logistical support concept. The mobile tank warfare pioneered by the Germans highlighted the fact that not only had tactical mobility been restored to the battlefield, but it had increased by an order of magnitude. These operations focused on the application of combat power through combined arms and the shock inherent in high-tempo operations. The necessary logistic change was in supporting the high tempo of operations—not just movement, but speed of movement. This was the primary failure of the logisticians—the failure to recognize the need to support the tempo change—an intellectual and organizational change.

The Germans also failed in this regard. Although not apparent in the early campaigns, it was highlighted once they attacked into the wide-open spaces of the Soviet Union. Although the logistics failure was not the sole or perhaps even the primary cause of the German defeat on the steppes of Russia, it was a major contributor.

The Germans had only partially motorized their combat forces and only a small proportion of their logistics support was moved by truck. The remainder was tied to the use of railroads and animal transport. This weakness was masked in the campaigns in Poland and France by the relatively short distances and the rapid collapse of enemy forces. The vast distances encountered on the Russian Front, coupled with the resilience of the Soviet forces, served to expose this problem and caused the German soldiers to suffer horribly.[18]

The noted military historian, Williamson Murray explains that:

> Relations among technological innovations, fundamentals of military operations, and changes in concepts, doctrine and organization that drive innovation are essentially nonlinear. Changes in inputs . . . may not yield proportionate changes in outputs or combat dynamics.[19]

During periods of transition, in particular, there are significant intellectual, organizational and technological changes. The key change, however, must be intellectual change, for without intellectual change, technological change is essentially meaningless, and organizational change is impossible. Logisticians who grasp at technological change without making the necessary organizational and, more importantly, intellectual changes to fully understand and make best use of new technologies, are doomed to failure. Intellectual change is the requirement to make all others meaningful.

Implications for the Future

In order to examine the implications these lessons hold for the future of military logistics, one must first examine current views regarding the future of military operations. The US military has entered a period of rapid change. Orders of magnitude improvements in technology have resulted in recent attempts to devise long-range plans to incorporate those improvements into new weapon systems and operational concepts. *Joint Vision 2010* and the documents supporting its implementation provide the guidance for thinking about these new concepts.

In the logistics arena, *Joint Vision 2010* explains the concept of Focused Logistics—defined as

> the fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical levels of operations.[20]

The vision of Focused Logistics includes enhanced mobility and versatility of combat forces anywhere in the world through the elimination of vertical logistics organizations and the use of tailored combat service support packages and pinpoint delivery systems.[21]

Joint Vision 2010 heralds the creation of two other key concepts—dominant maneuver and full dimensional protection, the latter being simply the complete protection of forces and lines of communication *from fort to foxhole*. Dominant maneuver is envisioned as combat forces operating from dispersed locations in sustained all-weather, day or night operations at a decisive speed and tempo. It is "a prescription for more agile, faster moving Joint operations."[22]

The underpinning for all these concepts is the idea of information superiority—"the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same."[23] The *Concept for Future Joint Operations* explains further that the view of operations in *Joint Vision 2010* is predicated on the reduction of friction through greater battlespace awareness. This greater battlespace awareness is conceived as a comprehensive and complete view in space and time; using assured, secure and responsive information; and resulting in the capability to predict enemy intentions and actions.[24]

Given the nature of this vision of the future, the three historical lessons that are the subject of this analysis are clearly applicable. In general terms, these documents discuss the need for organizational change and they constitute at least an attempt at intellectual change. It is too early in the process of change to expect specific suggestions for modifications to existing military organizations. The intellectual change exhibited is part of the current debate regarding an ongoing *Revolution in Military Affairs*. A discussion of whether this revolution actually exists or not is beyond the scope of this article, but the authors of the Joint vision documents clearly believe it does.

Innovations do not necessarily result from new technologies. New technologies may simply be used to do existing missions better. Innovations occur when new procedures are built around changes in the way organizations relate to each other and to the enemy.

With regard to the best case-worst case lesson, it would seem the logisticians of the future would still be susceptible to the effects of this dichotomy. The concept of dominant maneuver is focused on speed, tempo and agility of operations—from dispersed locations. The logisticians' tasks would seemingly be made even more difficult than today. Those who compose this vision of the future would answer that the concept of focused logistics would enhance the mobility and versatility of the logistics forces to the point that they matched that of the combat forces. This is entirely possible, but given that history shows that combat forces are typically ahead of support forces in gaining improved capabilities, it is also entirely possible that logisticians will again find themselves in the position of their worst case being the best case operationally.

It is in the arena of friction and uncertainty that the US military's vision of the future would seem to be most lacking. Combat forces are visualized as smaller and more capable, supported by smaller and more capable logistics forces. The system of forces and support requirements is highly complex and interdependent with little or no slack or excess capability. These forces are to sustain operations around the clock, and success is dependent upon a continuous supply of vast quantities of absolutely accurate information. Although there are occasional disclaimers in the documents to the effect that fog and friction will remain, the concept belies these words—there is no discussion of how the system will cope with or overcome friction and uncertainty.

The only conclusion to be drawn is that the visionaries attempting to set the course for the future of the US military have failed to learn this lesson from the past. They are designing a tightly coupled system of systems. Within that system will exist interdependencies and implicit assumptions that will defy ready understanding and, therefore, result in unexpected outcomes. They are designing a system that is still subject to the vagaries and weaknesses inherent in human beings, but without taking those vagaries and weaknesses into account. They are designing a system which makes the logistics portion such a lucrative target that a potential enemy can have a greater impact by striking against logistics capability than by striking at combat capability. The failure to appreciate the effects of friction and uncertainty has had grave consequences in the past, and we are creating the potential for the same grave consequences.

These three lessons hold meaning for the future of military logistics. History has shown logisticians can fail if they do not understand the best case-worst case dichotomy, if they do not appreciate the need for intellectual and organizational change and if they do not take into account the effects of friction and uncertainty. While no one should expect history to repeat itself, logisticians can benefit from the study of history with a view toward understanding the errors of the past and the applicable lessons for the future.

The US military has entered a period of rapid change. Orders of magnitude improvements in technology have resulted in recent attempts to devise long-range plans to incorporate those improvements into new weapon systems and operational concepts.

Notes

1. *The Rommel Papers* as quoted in Martin van Creveld, *Supplying War: Logistics from Wallenstein to Patton,* Cambridge: Cambridge University Press, 1977, 200.
2. Chairman, Joint Chiefs of Staff, *Joint Vision 2010*, Washington, DC: Pentagon, 1996, 138-140, 199-210.
3. *Ibid*.
4. *Ibid*.
5. Julian Thompson, *The Lifeblood of War: Logistics in Armed Conflict*, Oxford, UK: Brassey's, 1991, 56, 61-67.
6. *Supplying War: Logistics from Wallenstein to Patton*, 213.
7. *Supplying War: Logistics from Wallenstein to Patton,* 212-213, 220-221.
8. *The Lifeblood of War: Logistics in Armed Conflict*, 50.
9. *Joint Vision 2010*, 13, 16, 22.
10. Carl Von Clausewitz, *On War*, trans and ed Michael Howard and Peter Paret, Princeton, New Jersey: Princeton University Press, 1976, 120-121.
11. *The Lifeblood of War: Logistics in Armed Conflict*, 278-279.
12. Barbara W. Tuchman, *The Guns of August*, New York, New York: MacMillan Publishing Company, 1962, 74-75, 79.
13. *On War*, 119.
14. Charles Perrow, *Normal Accidents: Living with High-Risk Technologies,* New York, New York: Basic Books, 1984, 4, 11-12.
15. Chris C. Demchak, *Military Organizations, Complex Machines: Modernization in the US Armed Services*, Ithaca, New York: Cornell University Press, 1991, 3-5.
16. *On War*, 95.
17. Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military*, Ithaca, New York: Cornell University Press, 1991, 134. See also Williamson Murray and Allan R. Millett, *Military Innovation in the Interwar Period*, New York, New York: Cambridge University Press, 1996, for a book-length treatment of this subject.
18. Matthew Cooper, *The German Army 1933-1945*, Lanham, Maryland: Scarborough House, 1978, 311-312, 331.
19. Williamson Murray, "Innovation: Past and Future," *Joint Forces Quarterly*, Summer 1996, 52.
20. *Joint Vision 2010*, 24.
21. *Ibid*.
22. *Joint Vision 2010*, 20-21.
23. *Joint Vision 2010*, 16.
24. *Concept for Future Joint Operations* (Preliminary Draft Version 4.0), Fort Monroe,Virginia: Joint Warfighting Center, 21 Mar 1997.

Successful operations depend on the entire wing organization working as a team with but one purpose in mind. The purpose, of course, is to make certain of the destruction of the selected target at exactly the right time and place. All of the years of planning and training, and the great financial and personal costs and sacrifice, will be vindicated by the successful execution of the mission; likewise, all will be wasted by failure, regardless of its cause.

—Air Force Manual 51-44, 1953

Forces that cannot win will not deter.

—Gen Nathan F. Twining, USAF

Daniel McConnell
Richard A. Hardemon
Senior Master Sergeant Larry C. Ransburgh, USAF, Retired

The Logistics Constant Throughout the Ages

War often conjures pictures of combat and large armies moving to the field inspired by a clash of political ideologies or ambitions. Indeed, the intriguing twists and nuances of the strong political current sweeping every conflict forward or the intricate strategy and battlefield tactics that vie for positional dominance can hold one's attention to the exclusion of all other aspects of war. Yet the bulk of a commander's considerations involve the logistical limitations that drive changes to strategy and tactics in order to keep forces supplied and moving. All manner of logistical supplies are necessary to carry on military operations. However, fuel (fodder for animals or petroleum, oil, and lubricants [POL]) holds a special importance in that its supply has influenced and often dominated strategy as long as nations or states have fielded armies.

Transportation of supplies and materiel preceding modern day machines relied on some form of pack animal, principally horses. The horse's need for fodder dictated to the commander the terrain through which he could campaign as well as the campaign seasons.

Following World War I, new modes of warfare made the use of pack animals obsolete; however, armies still employed them on a much smaller scale to move supplies. Technology—manifested in aircraft and mechanized vehicles birthed in the First World War and nurtured during the interwar period—required a new type of fuel in the form of POL. During World War II, in the European theater, massive armies raced across battlefields, and mechanized equipment greatly increased the spectrum of strategic possibilities. However, commanders still had to account for logistical considerations that would influence their tactics. Increasingly, POL dominated their strategy and tactics. Further, POL products accounted for the majority of supplies shipped into theater during the war.

Regardless of its modern connotation, POL's intrinsic equivalent throughout history has been fodder.

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Military Campaigns, Strategy, and the Need for Fodder

Most great commanders in ancient times, such as Alexander the Great, attempted to limit the number of horses on the campaign by ordering the troops and their attendants to carry many of their own supplies.[1] Yet, historian Donald Engels notes that pack animals were still necessary to carry "the army's noncomestible supplies, such as tents, hammocks, medical supplies, the ambulance, siege machinery, firewood, booty, and perhaps some of the women and children."[2] Though Alexander managed to significantly reduce the number of pack animals, Engels estimates that his army probably had about 6,000 cavalry horses and 1,300 baggage animals. Under the most favorable conditions, where the army campaigned in areas abundant in fodder and only needed to carry 1 day's supply of grain, they still needed approximately 1,100 pack animals to carry 269,000 pounds of grain, if each horse carried 250 pounds.[3] Engels notes that if an army traveled through an area devoid of fodder the number of pack animals needed to transport the grain and fodder requirements for 1 day would jump to 8,400 carrying approximately 1,260,000 pounds.[4] Noted historian Martin van Creveld, in *Supplying War*, similarly describes a generic premechanized army in which "the 40,000 animals accompanying an army would, therefore, require 800 acres per day."[5] Horses were imperative in a campaign, yet their subsistence greatly strained an army's resources.

Prior to the 18th century, few improvements were made to ease the fodder supply problem in Europe. In fact, the French made the problem worse by bringing extra men on the campaign to forage for fodder in the army's immediate vicinity. Historian John A. Lynn estimates between "4,000 and 10,000 men [were] necessary to mow forage for an army of 60,000"—each day a horse required approximately 24 pounds of dry fodder.[6] Interestingly, the French did maintain a magazine system to store troop provisions; however, the need to keep moving to find more fodder tended to cause the army to move too far and too fast away from this system of supply.[7] The ever present need to forage for more fodder forced the French Army to constantly move even when strategy dictated that it should not.

Strategy had to be adapted to account for horses' needs. Most historians agree the challenge of providing for the pack animals overshadowed the troops' provisions. Accordingly, the fodder requirement restricted an army's area of operations to regions that could sustain a high fodder intake. During the winter months when cold weather made fodder impossible to secure, armies were unable to campaign, and military operations necessarily became a seasonal activity.[8] Notably, in the 13th century, the Mongols possessed horses that could find food under the snow, so their time frame for waging war was greatly increased.[9] Early conquerors bypassed cities and only occasionally conducted sieges, as fodder in the immediate area quickly ran out.[10] Intuitively, the massive effort required to forage dictated strict precautions to prevent being surprised while gathering fodder. Though other factors also influenced strategy, the need for fodder dominated both strategic planning and military operations.

As long as armies required horses for cavalry and carrying supplies, the need to find fodder restricted flexibility and operations.

Throughout the first millennium AD, the Muslims were adamant about incorporating knowledge of terrain and vegetation when planning raids. Muslim planners devised contingency plans dependent on the seasons in that, during February and early March, their raids only lasted 20 days so they could get the horses back to Muslim territory to graze. Spring campaigns could only last 30 days, while summer ones were to last 60 because of the availability of fodder.[11] However, the Muslims were also sufficiently organized to set up a series of warehouses near their eastern frontiers over which they campaigned. Reports of these warehouses came in the 7th century and again in the 10th century relating the existence of ready supplies, "including grain and fodder [and] located where defensive or offensive action tended to repeat itself."[12] Despite the Muslims' successes, by the 18th century, few countries, except for the French and Prussians, had adopted a suitable fodder magazine system.[13] The French and Prussian magazine system, as well as the earlier Muslim warehouses, gave their respective forces the advantage of surprise and a greater measure of flexibility by allowing them to mobilize and attack more quickly.

As mentioned earlier, Alexander the Great grappled with the fodder problem throughout his far-flung exploits across Europe. Alexander realized the problems posed by bringing along numerous horses and pack animals, so he attempted to minimize their numbers by requiring his men to carry packs.[14] He also understood that excessive work and not enough food would wear out his cavalry and pack animals and he would not be able to nurse them back to health.[15] Welfare for the horses dictated that he slow his army's pace so the horses and pack animals could graze. The need to move faster, therefore, motivated Alexander to look for new ways to reduce his dependency on horses. His massive fleet helped alleviate this problem by transporting large fodder supplies from port to port, though this locked him into a dependency on the Mediterranean coastline or large navigable rivers, especially during winter.[16] The need to provide fodder for his horses forced Alexander to work within increasingly narrow boundaries as he moved farther away from Macedonia. Alexander's campaigns provide one of the earliest recorded examples of logistical handicaps.

As long as armies required horses for cavalry and carrying supplies, the need to find fodder restricted flexibility and operations. In 1775, during the American Revolutionary War, American forces under General Philip Schuyler planned an invasion of Canada. However, lack of rain made for a hot, dry summer, and General Schuyler could not move up enough fodder to feed the horses needed for a full invasion. Instead, the lack of fodder forced him to wait until late summer when adequate rain nourished the grass enough to supply the invasions.[17] Winter quickly set in after Schuyler experienced early successes and cut him off from all resupply. The "inadequate forage in June and July was not the only reason for the failure of the Canadian campaign, but it surely was one of them."[18]

Fodder further affected flexibility during the American Revolution when free fodder became hard to obtain and the Colonial Army had to compensate farmers for using their land. Wartime prices steadily rose as good pastureland became less available. However, like

Alexander, the American commanders understood that without adequate fodder their limited supply of horses would dwindle. Colonial commanders could send the cavalry away from the army to find cheaper fodder, but they needed the pack animals to stay close and often paid high prices for their nourishment."[19] Without the pack animals, the army could not transport its supplies and conduct operations for very long.

The US Civil War (1861 to 1865) demonstrated the importance of using a rail system to increase strategic flexibility by more efficiently supplying armies. Trains and rail lines came under attack as both sides sought to cripple the other's access to them and prevent valuable supplies from reaching their intended forces. Armies still required cavalry and pack animals to move their food and supplies while in the field and, therefore, continued to need fodder. However, with the locomotive's introduction into warfare, fodder and other supplies could be loaded onto trains and brought to depots within the army's proximity. Established supply lines could then be used to retrieve the materiel. The Civil War became the first conflict in which armies used the new technological innovation to improve logistics, especially resupplying fodder, and to alleviate the need to constantly change camps to find more fodder.[20] In fact, historian James A. Huston, in *The Sinews of War: Army Logistics 1775-1953*, relates that shipments of forage during the winter months averaged $1M. He goes on to say that fodder continued to dominate supply considerations, in that "for tonnage and bulk the item of daily supply that was even more important than food for the men was food for the animals."[21] Trains permitted armies to receive more fodder while maintaining their positions and simultaneously allowed an army to keep more horses.

The period between the Civil War and World War I was filled with advances in technology, which were not fully taken advantage of by the European powers. Further, the dominant powers in Europe (France, Prussia, England, and Russia) failed to truly understand the lessons that could have been learned from the Civil War. Cavalry charges and long baggage trains of horse-drawn wagons persisted, and with that returned the age-old need to feed the livestock. In many ways, the First World War resembled all past wars. However, its rapid consumption of supplies, especially ammunition, dictated that the times and ways of war were changing. But for the moment, it was remarkably similar to the past, in that during the war, Great Britain shipped 5,253,538 tons of ammunition to France as well as the greatest single item shipped, which was 5,438,602 tons of oats and hay.[22] Fuel for horses continued to be a dominant factor.

Regardless of the lessons the Germans should have learned from the past, during World War I, they placed a huge emphasis on cavalry and did not prepare for their maintenance in the field. The German high command ordered commanders to feed their horses off the land as a result of the army's sheer numbers of horses. Van Crevald relates that any attempt to supply the army from home bases would have been impossible.[23] As the Germans moved into France early in the war, luck appeared to be with them as the land was rich and the grain had just been harvested. However, much of the grain was still green, causing many of the horses to become sick and die very early in the campaign. A critical shortage in fodder resulted, and by the time of the Battle of the Marne, where French and British forces engaged and halted the German advance, most of the horses were too weak to keep up the pace.

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The German invasion plan, known as the Schlieffen Plan, depended on the speed of the invasion, yet the horses employed in reconnaissance and pulling the heavy artillery were so poorly fed that they could not keep up the pace. Many died before the Germans crossed the border into Belgium. By 11 August 1914, preceding the Battle of the Marne, cavalry forces ordered a 4-day halt to find food for the mounts.[24] By the Battle of the Marne, the starved horses pulling the German artillery, which was the only arm that had a distinct advantage over French forces, could not keep up the pace. "By this time, too, one German army at least was finding that the state of the cavalry seriously interfered with operations."[25] The German high command's severe lack of oversight of properly feeding the horses proved to be a decisive factor in the failure of the Schlieffen Plan.

Following the offensive stall after the Battle of the Marne, the consumption of supplies reached proportions unmatched by any previous war. However, this consumption rate could not have been maintained if the front had not stalled and remained stationary throughout the war.[26] Supply movement via horses would have been inadequate given the war's immense scale. Toward the end of the war, both sides began to introduce motorized transport on a very small scale and began to argue that "complete motorization of local transportation and the widespread use of combat vehicles would restore mobility to the battlefield."[27] Petroleum products, then, came into demand, and by the war's end, more than

759,000 tons of gas and oil had been shipped onto the Continent. War planners deemed the horse obsolete in favor of the more economical and faster moving petroleum-based machines.

Military Campaigns, Strategy, and the Need for POL

Following the First World War, armies began nurturing the technological innovations employed at the end of the war and subsequently developed a strong dependency on petroleum products by the beginning of World War II. POL significantly differed from fodder in that POL had to be manufactured away from the battlefield and then shipped to the battle area.[28] For the most part, fodder as a source of fuel for horses quickly became a thing of the past as armies became fully mechanized. The new machines could be worked harder and go farther and faster, and most important, the time of the year and the route taken by the army did not affect its fuel supply. Commanders could expand their range of strategic operations immensely and do more with less.

However, challenges quickly attached themselves to the new machines and their fuel supply. If army quartermasters did not constantly provide the machines with enough fuel, operators could not normally forage for it. In this respect, commanders lost a measure of flexibility, and the situation forced them to further employ technology to devise ways to overcome the new problems. The result involved underground pipelines and the `Red Ball Express`, in which a constant stream of trucks traveled distances of up to 400 miles to supply Patton's Third Army.

The German invasion plan, known as the Schlieffen Plan, depended on the speed of the invasion, yet the horses employed in reconnaissance and pulling the heavy artillery were so poorly fed that they could not keep up the pace.

The beginning of World War II saw the German Army still reliant on horse-drawn transport. Hitler neglected to fully mechanize his transport vehicles, though he dramatically increased the number toward the end of the war.[29] Historian Julian Thompson relates that the Germans only possessed three motor transport regiments, for the whole army, capable of carrying 19,500 tons. In 1944, the Allies in northwest Europe could transport 69,400 tons to support 47 divisions. Thompson goes on to state, "Hitler's failure to build up the necessary capacity to provide the transport essential for mobile warfare was one of the principal reasons for the failure of the German invasion of the Soviet Union (Operation Barbarossa)."[30] Regardless of the German Army's deficit in mechanized transport, the Second World War became the pioneering conflict to be predominantly affected by fuel in the form of POL.

Following Germany's invasions of Poland and France, POL's role became readily apparent, and Allied strategists sought to cripple the Axis' ability to effectively employ fuel with US entrance into the war. Plans got under way to target the Ploesti oilfields in Rumania as strategists estimated that the fields had the capacity to produce 9 million tons of refined oil per year, though it only produced 4 million. Allied strategists understood well the Germans' primitive transportation system and the fact their small fleet of motorized transport vehicles had become extremely overburdened by the war's rapid geographic expansion.[31] Accordingly, the Allies did not attack Ploesti in the hopes of crippling the Axis refining capacity. Instead, they were more interested in destroying Ploesti's refining capability so Germany's limited transportation system would have to move the crude oil from the Ploesti area to other refining sites in Germany or France. The war had already severely taxed the Axis transportation system, and the Allies believed the extra strain would cause supply to other areas to fall apart.

The Allies launched the first Ploesti raid on 1 August 1943 and estimated that the Axis oil supply had been reduced by 3 or 4 percent.[32] It was originally believed the raid had destroyed about 40 percent of 6 months of Rumanian refining capacity or a loss of 1.8 million tons of refining capacity as a result of closing the refining facilities from about 1 week to several months.[33] However, the raid's after-action analysis indicated that Rumanian oilfields possessed twice their estimated production capacity, so subsequent raids would have had to destroy about 3 million more tons of refining capacity to begin really limiting Ploesti's actual refining capacity.[34] Though the mission proved to be successful, the Army Air Forces sustained a 30 percent loss, making a follow-up raid impractical.[35] The Allies moved on to other targets, and the Germans managed to quickly rebuild the facilities.

Evolving into a strategy to attack the entire Axis oil industry, the raid, despite its heavy losses, fueled an intense bombing campaign that managed to strike every major oil refinery in German-controlled territory. Ambitiously, the United States and Great Britain set out to severely damage the German oil industry and keep it subdued. Like Ploesti, the Allies' goal was to reduce the German refining capacity as well as the number of refineries available to cannibalize in order to rebuild larger, more productive refineries.[36] They wanted to present Germany with only two options: transport the crude oil to old unattacked refineries near

Marseilles, France, where they were highly vulnerable, or stay in their present locations and attempt to rebuild between raids.[37] The Germans chose the second option, and the Allies timed return missions to prevent refineries from going back on line.[38] As German oil production suffered, so did its armed forces as lack of aviation grade fuel kept the Luftwaffe on the ground and forced the army to heavily dip into rapidly dwindling reserves.

The Germans failed to completely think the entire war effort through and suffered from inadequate fuel reserves. The German Oil Association advised the government that the oil reserves would only last for 5 months given the high rate of consumption. Germany made the reserves last longer by robbing from the civilian sector, but the effects of the Allied bombing after 1943 made the situation critical. Germany's aggressions in 1939 and 1940 were rewarded with its victims' oil reserves. A US investigation following the war relates, "In January 1941, aviation gasoline stocks were approximately 500,000 tons. When Germany conquered the Netherlands, Belgium, and France, about 1 million tons were secured."[39] However, by January 1944, aviation gas had been reduced to 240,000 tons, and by January 1945, it was almost nonexistent.[40] By May 1944, fuel shortages resulted in a drastic reduction in training hours, and operational time was limited strictly to air defenses.[41] The situation had become so critical that the Luftwaffe could provide little opposition to the Allied invasion on 7 June 1944. By 1945, it could not support German ground forces in the Battle of the Bulge after a successful ground offensive.

Germany's lack of fuel reserves also manifested itself in ground operations as the Combined Bomber Offensive and the Allied advance prevented German recuperation. Following victory in North Africa and a successful invasion of Sicily, the Allies drove up the Italian peninsula until stiff German opposition along the Gustav Line halted their advance. The Allies initiated Operation Strangle from 19 March to 10 May 1944 to cut the Germans off from resupply and deplete their fuel reserves. Generally successful, Strangle did not dislodge the Germans, and Operation Diadem got underway on 11 May 1944 to increase German fuel consumption while reducing their resupply through interdiction.[42] Strategically, the Allies planned to dislodge the Germans while strategic bombing would prevent resupply in hopes they would run out of fuel.

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Operation Diadem went according to plan, and by mid-May, 14 fuel depots had been critically depleted, and "the mobility of the entire army had been called into question."[43] German fuel was adequate to compensate for the defensive maneuvers necessitated by the Allied advance at the beginning of the operation. Yet, by early June, the effects of the campaign presented a very hard reality. The German armies had been in retreat for a week, and the American Fifth Army presented a constant threat.[44] Though this defense suited the mountainous terrain and the situation, it required a lot of fuel that the army did not possess. "By June 6, the army was making its moves piecemeal—a unit would move, exhaust its fuel, and wait for resupply."[45] Defensive maneuvers, the mountainous terrain, and movement at night saved the German Army from total defeat, but fuel's use in strategy and its subsequent effect on German strategy was enormous.

On 6 June 1944, the Allies launched Operation Overlord, and the invasion of Eastern Europe began. Original plans called for the Allies to steadily push the German Army toward the Rhine and then force surrender. However, after a massive aerial bombardment on 25 July, the Allies forced a gap in the German lines and then exploited it by pouring through armored divisions.[46] New tactical opportunities to quickly defeat the Germans presented themselves instead of the originally planned methodical push to the Rhine."[47] Patton's Third Army raced through southern France consuming an average of 350,000 gallons of fuel each day.[48] By 7 August, the Third Army had exhausted its fuel reserves, though it managed to maintain the rapid advance for another 3 weeks. Fuel supply reached critical levels from 20 to 26 August when both the First and Third Armies, pursuing the retreating German Army, consumed an average of more than 800,000 gallons of gas a day.[49] However, the supply lines had not yet become so long as to be unmanageable by theater logisticians, and the Allies had enough fuel to enter Paris on 24 August.

Pre-invasion planning called for the Allies to halt and wait for the logistical network of communications and food pipelines. However, their shipping successes and rapid advances into Paris with little German resistance called for a reevaluation of the plan. General Bradley, commanding the First Army, was quoted as saying, "Armies will go as far as practical and then wait until the supply system in [the] rear will permit further advance."[50] Basically, he proposed to move forward, taking as much ground as possible, until they ran out of gas. Once again, fuel requirements dominated strategic decisions and operational action.

Since World War II, POL has become increasingly important to keep an army going in the field. The past 50 years of technological advance have only optimized modes of transportation, not lessened the impact of fuel on strategy, tactics, and operations. While technological advances may reduce the amount of support equipment required for military operations and the size, lethality, or amount of munitions—all of which will further reduce lift requirements—similar advance is seen as unlikely for fuel. Arguably, fuel will remain the dominant logistics factor that limits strategic and tactical planning as well as actual operations for the foreseeable future.

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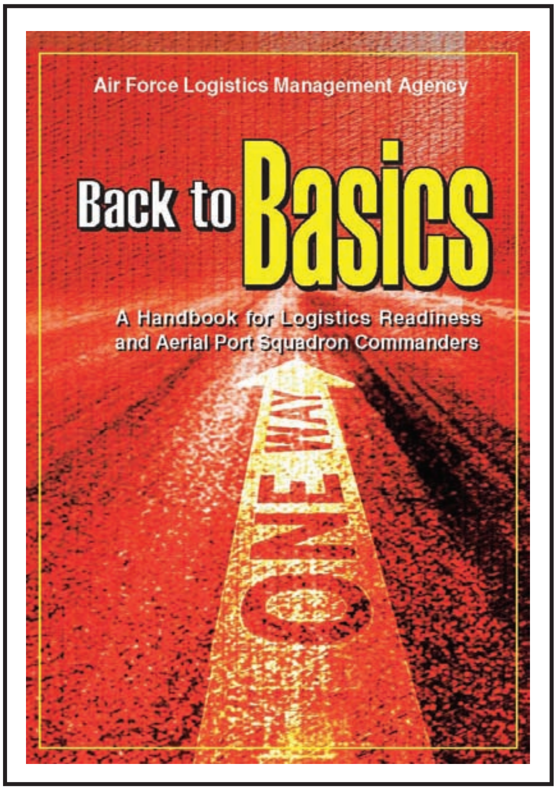
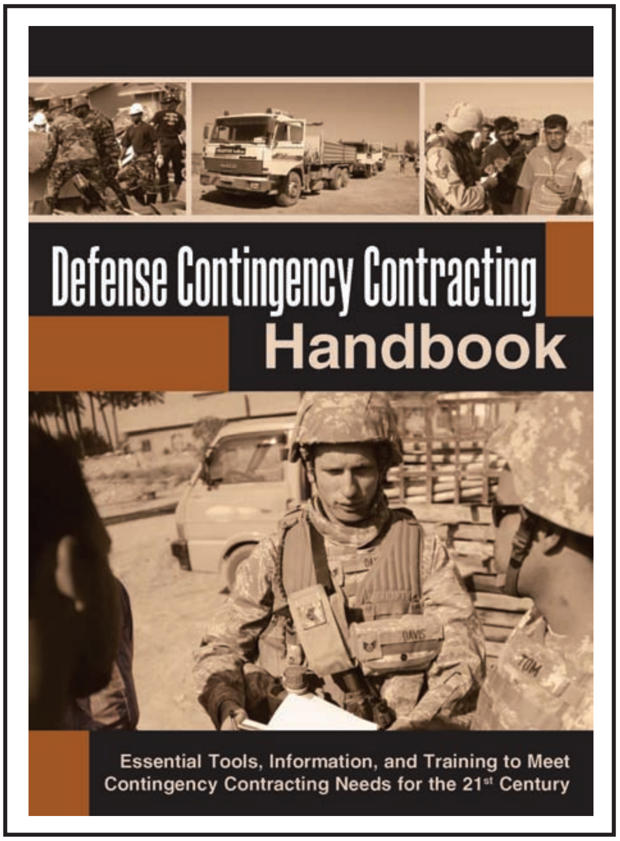
back to basics

This handbook is designed to serve as a quick reference functional guide. It is broken down by process, similar to the current logistics readiness squadron and proposed aerial port squadron structures. The areas covered include deployment and distribution, fuels management, materiel management, vehicle management, traffic management, and aerial port. The handbook also contains quick facts on high-profile logistics areas such as nuclear weapons-related materiel and the Air Force Global Logistics Support Center.





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Contingency contracting support has evolved from purchases under the simplified acquisition threshold to major defense procurement and interagency support of commodities, services, and construction for military operations and other emergency relief. Today, this support includes unprecedented reliance on support contractors in both traditional and new roles. Keeping up with these dramatic changes, while fighting the Global War on Terror, is an ongoing challenge. This pocket-sized handbook and its accompanying DVD provide the essential information, tools, and training for contracting officers to meet the challenges they will face, regardless of the mission or environment.

relevant, informative, and insightful

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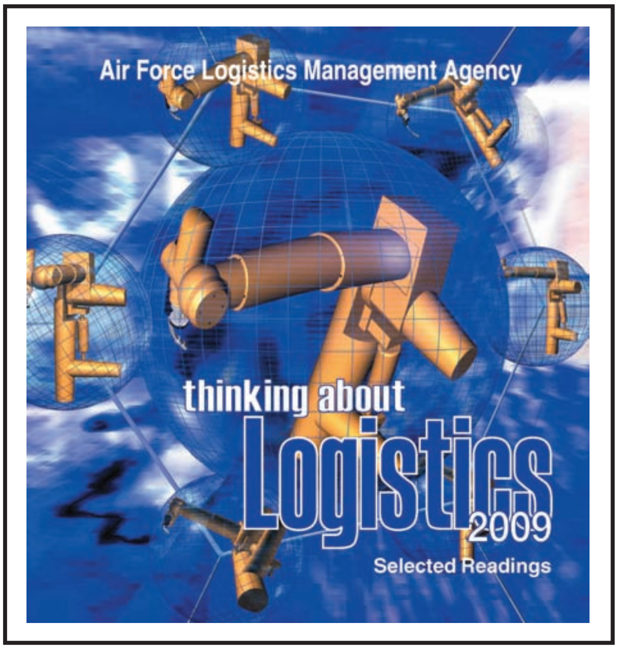
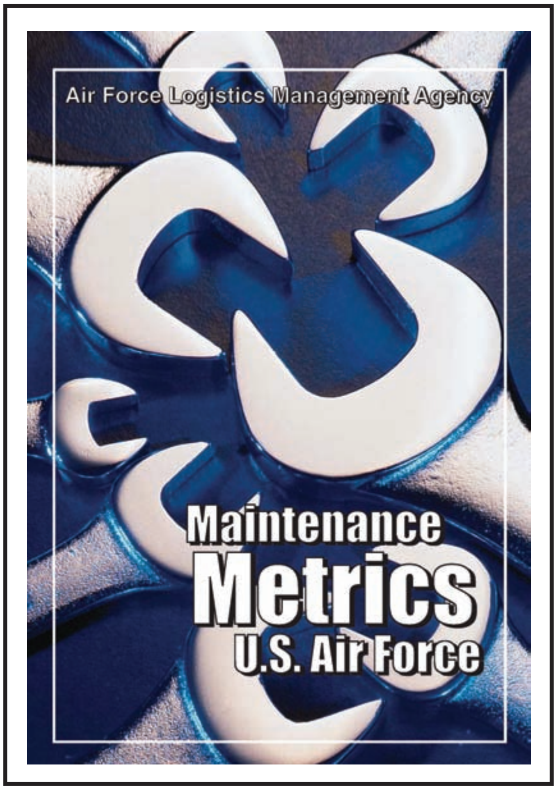
maintenance metrics

This handbook is an encyclopedia of metrics and includes an overview to metrics, a brief description of things to consider when analyzing fleet statistics, an explanation of data that can be used to perform analysis, a detailed description of each metric, a formula to calculate the metric, and an explanation of the metric's importance and relationship to other metrics. The handbook also identifies which metrics are leading indicators (predictive) and which are lagging indicators (historical). It is also a guide for data investigation. Limited quantities. New version in development.

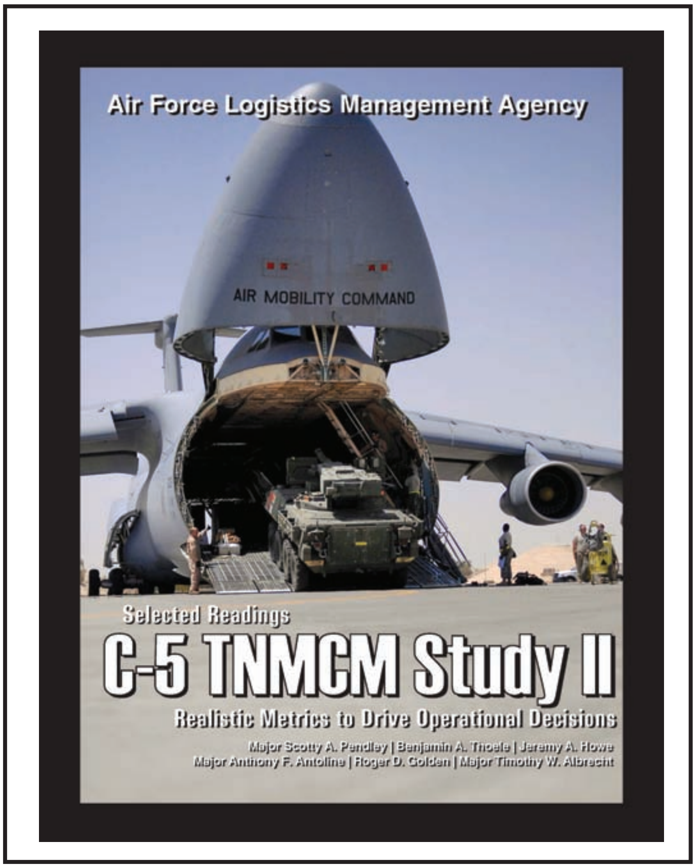


thinking about logistics 2009

Thinking About Logistics 2009 is a collection of 37 essays and articles—in three sections: Historical Perspective, Contemporary Thought and Issues, and Studies and Analyses—that lets the reader look broadly a variety of logistics areas. Included in the volume is the work of many authors with diverse interests and approaches. The content of *Thinking About Logistics 2009*, ranging across approximately 10 years, was selected for two basic reasons—to represent the diversity of the ideas and to stimulate thinking.



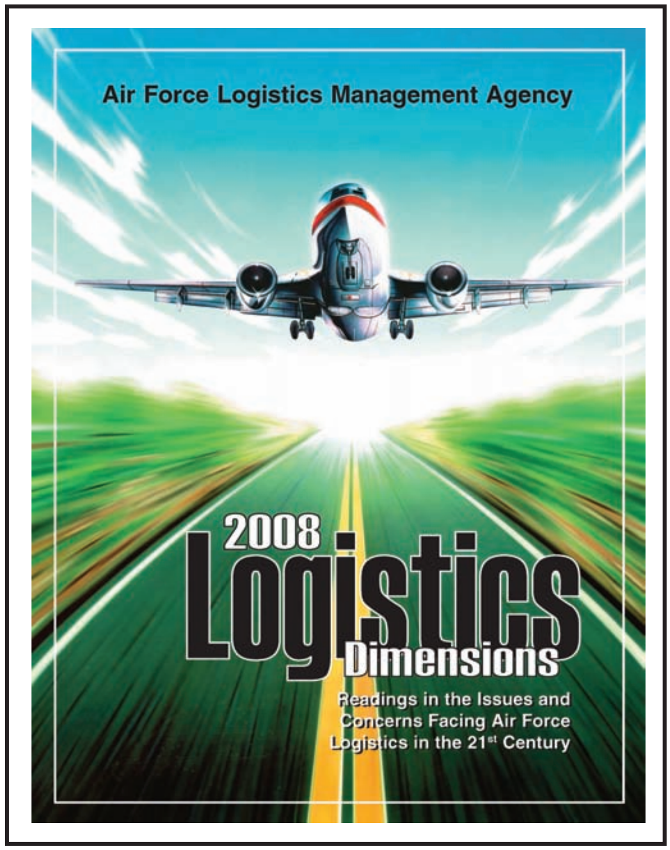
C-5 TNMCM study II



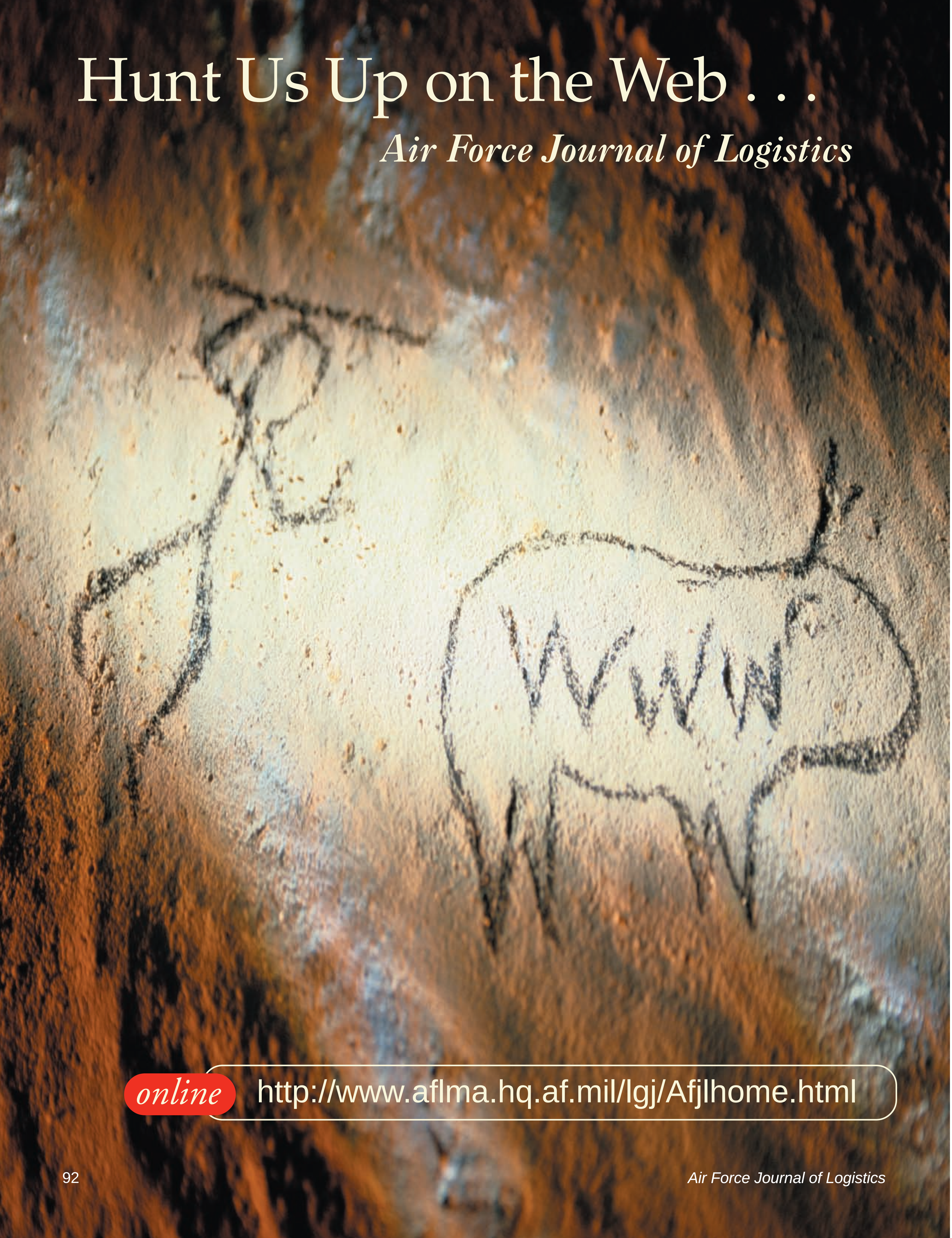
The *C-5 TNMCM Study II* proved to be a stern test of AFLMA's abilities and perseverance. The research addressed areas of concern including maintaining a historically challenged aircraft, fleet restructuring, shrinking resources, and the need for accurate and useful metrics to drive desired enterprise results. The study team applied fresh perspectives, ideas and transformational thinking. They developed a new detailed methodology to attack similar research problems, formulated a new personnel capacity equation that goes beyond the traditional authorized versus assigned method, and analyzed the overall process of setting maintenance metric standards. A series of articles was produced that describes various portions of the research and accompanying results. Those articles are consolidated in this book.

logistics dimensions 2008

Logistics Dimensions 2008 is a collection of 19 essays, articles, and vignettes that lets the reader look broadly at a variety of logistics concepts, ideas, and subjects. Included in the volume is the work of many authors with diverse interests and approaches. The content was selected for two basic reasons—to represent the diversity of the ideas and to stimulate thinking. That's what we hope you do as you read the material—think about the dimensions of logistics.



Have you noticed there seems to be a void when it comes to books or monographs that address current Air Force logistics thought, lessons from history, doctrine, and concerns? We did, and we're filling that void. Our staff produces and publishes selections of essays or articles—in monograph format—on a quarterly basis. Each has a theme that's particularly relevant to today's Air Force logistics. Informative, insightful, and in many cases, entertaining, they provide the Air Force logistics community the kind of information long taken for granted in other parts of the Air Force.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EXPLORING THE HEART OF LOGISTICS

Functional Experts for Campaign Planning: How Does the Air Force Develop Logisticians to Satisfy the Operational Level of War?

David Sanford, Lieutenant Colonel, USAF

Introduction

The impending requirements of the 21st century's emerging geostrategic landscape mandate a revolution in how Air Force logisticians are developed and educated. This education must create a comprehensive vision to deliberately *grow* Air Force logisticians with the necessary functional expertise to provide critical, time-sensitive advice to combatant commanders (COCOM) and commanders Air Force forces (COMAFFOR) as well as prepare combat forces (organize, train, and equip) to carry out the commander's intent. The United States military entered the 21st century prepared to conduct force-on-force campaigns against nation states; however, shortly after the events on September 11, 2001, the military recognized the need to change its organization and culture to meet new challenges in the world. The former secretary of defense, Donald Rumsfeld, highlighted the need for greater flexibility and agility.

> We entered the century really arranged to fight big armies, big navies, and big air forces, and not to fight the shadowy terrorists and terrorist networks that operate with the support and assistance of terrorist states. And that's why we are so focused on transforming the department and the Armed Services. To win the Global War on Terror, the Armed Forces simply have to be more flexible, more agile, so that our forces can respond more quickly.[1]

In 2004, the Joint Chiefs of Staff (JCS) issued a revamped Focused Logistics Campaign Plan. In this plan, the JCS Director of Logistics clearly states that future Joint warfighting will place extraordinary demands on our abilities to execute superior logistics support decisions.[2] The demands referred to in this plan go beyond just information collection and dissemination, but include the decisionmaker as well. The decisionmaker must possess the functional expertise to quickly understand the information and provide leadership and advice to either his or her staff or senior leadership. Accordingly, Air Force logisticians must transform their education and training paradigms to ensure they have the correct expertise to rapidly deploy and sustain forces for the COCOMs and COMAFFORs.

According to Joint Publication 3-0, *Doctrine for Joint Operations*, the operational level of war is defined as:

> The level of war at which campaigns and major operations are planned, conducted, and sustained to achieve strategic objectives within theaters or other operational areas. Activities at this level link tactics and strategy by establishing operational objectives needed to achieve the strategic objectives, sequencing events to achieve the operational objectives, initiating actions, and applying resources to bring about and sustain these events.[3]

The operational level of war is a complex, fast paced environment in which the initial plans and guidance for subordinate units to execute are provided. An initial plan may developed by generalists, but eventually those generalists must become subject matter experts capable of planning and executing logistic support for theater-level operations. Logistics expertise, like operations, medical, and communications, is paramount to ensuring a plan's success. Logisticians analyze the deployability and sustainability of any campaign plan. By having well trained and educated logistics subject matter experts on staff, the COCOM and Air Force Forces (AFFOR) staff can expedite decisionmaking, possibly ahead of the enemy's decisionmaking cycle, and compress planning time lines.

The Air Force logistics community has approximately 383 field grade officer (FGO) positions assigned to the various geographic COCOM, functional COCOM, and AFFOR staffs.[4] This represents approximately 51 percent of logistics FGO positions across the Air Force. Thus, a majority of Air Force logistics FGOs and some company grade officers (CGO) will find themselves working on a COCOM or AFFOR staff conducting crisis action and contingency operations planning. Like other career field specialties, these officers will be valued for the expertise in logistics; therefore, the Air Force must develop an education strategy to deliberately develop logisticians with the necessary functional skills to provide timely, accurate advice to combatant and AFFOR commanders.

Operations

Issue Background and Significance

What is logistics? Officers are told it is important, but not exactly why. It is often discussed in professional military education, but not in great detail. It seems to encompass all things that are not operational or medical. Martin van Creveld provides a succinct definition. He stated, that after the COCOM or AFFOR identify the center of gravity, "the feeding into it of men and material is a question of bases, lines of communication, transport, and organization—in a word, logistics."[5] Joint Publication 4.0, *Doctrine for Logistics Support for Joint Operations*, defined logistics in this way.

The science of logistics concerns integration of strategic, operational, and tactical sustainment efforts while scheduling the mobilization and deployment of units, personnel, equipment, and supplies in support of the employment concept of the geographic combatant commander. The relative combat power that military forces can bring to bear against an enemy is enabled by a nation's capability to plan for, gain access to, and deliver forces and material to the required points of application across the range of military operations.[6]

Logistics is the *magic behind the curtain* that deploys, receives, integrates, sustains, and redeploys Air Force units to successfully execute COCOM and AFFOR objectives around the globe.

In 2002, the Air Force combined the transportation, supply, and logistics plans Air Force specialty codes (AFSC) into the logistics readiness officer (LRO) AFSC.[7] For the purposes of this article, the term Air Force logistician refers to the former Air Force supply, transportation, and logistics plans career fields. The terms Air Force logistician and LRO may be used interchangeability, but they both refer to core Air Force logistics officers. It does not include aircraft maintenance or munitions. The Air Force's vision was to create a logistician that mirrored its sister Service counterpart who could perform more effectively in the Joint environment. Field grade officers in the former career fields were *grandfathered* and immediately became fully qualified LROs. Former transportation, supply, and logistics plans company grade officers (CGO) who had two years experience in their current AFSC and who had successfully graduated from their technical training were classified as *round-out* officers. These officers were required to complete one rotational assignment in something other than their *core* specialty and computer-based training courses in the other *noncore* areas.

Article Acronyms

ACS – Agile Combat Support
AFFOR – Air Force Forces
AFPC – Air Force Personnel Center
AFSC – Air Force Specialty Code
ALMC – Army Logistics Management College
AQD – Additional Qualification Designator
CFETP – Career Field Education Training Plan
CGO – Company Grade Officer
COCOM – Combatant Commanders
COMAFFOR – Commander Air Force Forces
CYOS – Commissioned Years of Service
FGO – Field Grade Officer
GWOT – Global War on Terror
ILO – In Lieu Of
JCS – Joint Chiefs of Staff
LOOP – Logistics Officer Orientation Program
LREC – Logistics Readiness Expeditionary Course
LRO – Logistics Readiness Officer
LRS – Logistics Readiness Squadron
O-6 – Colonel Designation
OEF – Operation Enduring Freedom
OIF – Operation Iraqi Freedom
OJT – On-the-Job Training
ONE – Operation Noble Eagle
OSD – Office of the Secretary of Defense
SEI – Special Experience Identifier
SOC – Support Operations Course
US – United States

In the midst of this transformation, the Air Force was conducting Operation Enduring Freedom (OEF), followed very quickly by Operation Iraqi Freedom (OIF) in 2003. Thus, LROs found themselves faced with the challenges of operating effectively in the Global War on Terror (GWOT), while learning new disciplines and leading new combined organizations. Despite these challenges, the LRO career field must find a way to strike a balance between the requirements to have senior leaders with a broad understanding of logistics with the requirement to retain some number of leaders with depth in a single core competency.

Jomini states, "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."[8] In order to determine the overall effectiveness of logistics in military operations and the performance of LROs, the author reviewed several lessons learned documented from recent operations. An overarching theme of all lessons learned documents was that while recent operations such as Operation Allied Force, Operation Noble Eagle (ONE), OEF, and OIF were overwhelming combat successes, logistics performances appeared to fall behind other functional successes. As far back as 1999, Air Combat Command's Agile Combat Support (ACS) concept paper denotes the need for logistics support personnel training requirements for multiple related (cross functional) skills as well as advanced education and specialty training requirements to maximize effective ACS implementation.[9] As part of the lessons learned for OIF, the Office of Secretary of Defense (OSD) identified fundamental challenges for logistics support to the warfighter. Information and processes remain stovepiped, in-theater planning and resources were insufficient, and the lack of flexibility and responsiveness of the logistics chain required numerous ad hoc solutions for basic needs.[10] Lack of training in Joint interoperability is evident throughout the lessons learned. When discussing the development of a true Joint logistics staff capability, OSD stated:

Leadership must recognize that the growth and development of *Joint logisticians* who can operate and lead effectively in the theater environment will take time and effort, potentially altering established career progression plans.[11]

Furthermore, the Government Accountability Office on logistics effectiveness during OIF states, "Military personnel were not adequately trained in various logistics functions, such as…operating theater logistics centers."[12]

Beyond the execution phase of operations, most lessons learned identified training and education as reasons for shortcomings in support. Most reports discounted the phrase "train as we fight" and identify the need for the Air Force and other Services to formalize their Joint training and education programs. Indeed, the Air Force's installations and logistics lessons learned final capstone report on ONE and OEF emphasizes the need for the Air Force to establish regular training within the Joint environment, training with special operations forces, and exercises and training for liaison officers for placement in Joint and coalition critical command and control nodes. The report further states that:

ACS training in Joint and combined operations is needed across functional areas to achieve interoperability as well as the need to establish a more formalized training program for coalition operations where collaborative planning, information-sharing, and common operational pictures are exchanged and shared with various coalition partners.[13]

Additionally, the report identifies several additional logistics themes. First, "forces not adequately trained to perform their missions" and "individual personnel are forced to haphazardly learn as they go" are recurring problems.[14] Another concern was lack of knowledge about "duties, responsibilities and procedures," citing recurring topics such as "confusion regarding Joint responsibilities," "lack of standardized procedures concerning how various US government agencies should interact," and "lack of guidance and concept of operations dealing with Joint forces interaction."[15] Other concerns in the report included time-phased force deployment data production, war reserve materiel processes, and inadequate in-transit visibility, fuels planning, and site surveys—all of which are part of the education and training program of today's Air Force logistician.[16]

The onset of September 11, 2001 and continuous, steady-state deployments have accelerated the need to revamp logistics officer education as it pertains to the operational level of war. As stated in multiple after action reports, the GWOT has identified shortcomings in logistics education and training at the operational level of war. These shortcomings are compounded by the heavy demands placed on LROs in the GWOT (constant deployments) which has shortened the Service's ability to make changes in logistics curriculum and training that will generate an immediate return on investment. According to Marine Corps Lieutenant Colonel Williams, a veteran planner during Operations Desert Shield and Desert Storm:

> This prerequisite to somehow acquire instant cross-functional expertise becomes paramount in the area of responsibility, where time is precious and every minute wasted learning on the job is a minute closer to mission failure. If logistics cannot support the sequence of events in the operational plan, it is not a plan at all but simply an expression of fanciful wishes.[17]

It is difficult for any officer to instantly know and understand operational level or theater-wide logistics planning; however, proper, well structured education and training can minimize the learning curve and ensure logistics is always ready to successfully execute the operational plan.

Senior Air Force Logisticians' Perspectives

In addition to reviewing lessons learned from recent operations, a series of interview questions were prepared and distributed to senior Air Force logisticians (colonel). The interviews represented an initial qualitative study to validate lessons-learned reports and the need to conduct this initial research project. The interview questions were coordinated with the LRO career field manager for appropriateness, succinctness, and clarity. The career field manager felt the interview questions were critical to the success of the research to help determine the *pulse* of senior Air Force leadership. Once approved, the questions were electronically mailed to 104 colonels assigned to logistics positions as well as core senior Air Force logisticians; however, because of leave, deployments, and personal issues only 101 officers could respond to the interview questions. In consideration of senior Air Force logisticians' personal demands on time, the interview was limited to five questions. Prior to the distribution of the interview questions, the LRO career field manager sent an electronic mail encouraging the senior Air Force logisticians to complete the survey and provide as much details as possible to assist in furthering this research project.

The issues of education, training, and how many logistics experts versus specialists are needed have been discussed among senior Air Force logistics leadership for some time. A qualitative analysis of the interview responses supported some of the findings from the lessons learned documents as well as provided a senior-level perspective on whether Air Force logisticians are both prepared educationally and trained to perform at the operational level of war. During the interview, officers were asked the following question.

> In your experience, are Air Force logisticians prepared both educationally and with training to perform at the operational level of war? For example, do you feel that we effectively *grow* LROs to serve as Joint planners on COCOM staffs? If not, what are some of your recommendations?

The respondents answered the question with a simple yes or no (as designed). Approximately 75 percent of senior Air Force logisticians responded that they believe Air Force logisticians are not adequately prepared through education or training to operate at the operational level of war. Only 16 percent of senior officers thought Air Force logisticians were prepared to function at the operational level of war, while 9 percent were neutral or noncommittal. The large number of senior officers concurring with the question clearly indicates that a greater focus should be placed on training and educating Air Force logisticians to operate at the operational level of war. In fact, one senior officer said:

> I think we end up [referring to current logistics education and training] with a jack-of-all trades and expert at none. Sometimes a little knowledge is good, but when you need to resolve a thorny issue you want a subject matter expert.

In addition to the first part of this question, most respondents provided detailed commentary on the challenges facing Air Force logisticians at the operational level. A majority of respondents (66 percent) believed more emphasis should be placed on teaching Joint doctrine and concepts at the CGO level. This foundation ensures Air Force logisticians are better educated and trained to operate at all levels of war. Finally, 15 percent of senior Air Force logisticians believe more wholesale logistics training and education is needed. Wholesale logistics involves the acquisition, purchasing, and distribution of supplies and equipment to end users in the field. It is commonly associated with the depots of Air Force Materiel Command or the Defense Logistics Agency.

The second interview question requested respondents identify what critical skill sets are required to perform as an Air Force logistician. All 44 respondents unanimously agreed that the five core competencies identified on the survey (material management, air transportation, distribution, contingency operations, and fuels) were the correct core competencies or functional expertise that Air Force logisticians should be educated and trained for in order to successfully perform at all levels of war. The respondents did not identify one competency as being more important than the other. One anonymous senior officer stated:

> We need to grow a certain number of officers with extended expert knowledge in specifically targeted areas like contingency operations and distribution. Our challenge will be identifying this select set early and keeping them on track with the right training, education, and job experience to fill the requirement.[18]

More than 80 percent of the respondents believed that some pool of Air Force logisticians should specialize in the core competencies identified previously, while others should remain more generalist, capable of advising, working in any of the various competencies, but unable to provide knowledge of the subject area.

The remaining questions on the survey yielded qualitative data that was instrumental in shaping proposed career field paths for Air Force logisticians. The goal is to develop a logistics career path that provides the right, future expertise needed for officers to successfully understand and execute at the operational level of war. As one anonymous logistics colonel stated: "My experience on [a] combined staff in Korea was that we threw folks in the pool and they either swam or failed with little applicable training or support."[19] This view is from a respondent with multiple tours on Joint staffs to include an assignment at United States Forces in Korea (USFK). Unfortunately, this reply was not isolated and reverberated across the interview respondents. It is obvious that the Air Force must better prepare its logisticians to succeed at the operational level of war. The recommendations and suggestions provided by the senior Air Force logisticians were tailored by the officer's own personal experiences, but taken together, provided almost 900 years of experiences. These suggestions and recommendations are addressed later in more detail.

Education

In order to help shape future education and training requirements for Air Force logisticians, a review of current Air Force logistics officer education and training programs, as well as a review sister-Service programs, was conducted. The Navy's supply officer corps and the Army's quartermaster and transportation officer duties closely resemble the Air Force logistician in mission scope and responsibility. A brief overview is provided on Air Force and sister-Service training and education in the following sections. A comparison with the Marine Corps logistics education and training program was not possible because of other mission needs and competing priorities at the time. A cursory review of their logistics officer corps identifies 15 distinct officer specialty codes that including ordnance, maintenance, embarkation officer, making a sister Service comparison very difficult.

Current Air Force Logistics Education Program

The basis for educating and training the Air Force logistician can be found in the Career Field Education Training Plan (CFETP). The document was reviewed to determine mandatory Air Force logistician training requirements. Only two courses are described as mandatory for Air Force logisticians. They are the Logistics Readiness Officer Basic Course and the Logistics Readiness Expeditionary Course (LREC). The current Air Force logistics training and education path is shown in Figure 1.

Before the officer attends his or her in-resident technical school training, unit commanders or equivalent are expected to develop and implement rotational training plans that allow junior LROs the opportunity to experience different functional areas. According to the CFETP, the objective of this program, known as the Logistics Officer Orientation Program (LOOP), is "to provide a foundation for their career in logistics readiness."[20] Additionally, LOOP provides the Air Force logistician an introduction and familiarization of information systems, processes, and programs prior to the officer attending formal technical training. This provides the officer with maximum opportunity to take advantage of technical training. LOOP is a three-phased program: Phase I consists of an initial interview, Phase II consists of LRS and support agency orientation, and Phase III consists of equipment and vehicle familiarization. In developing the orientation program, commanders should use mission briefs, tours, *shadowing*, and directive reviews to accomplish the objectives of the program.[21] As illustrated in Figure 1, newly accessed or cross-trained Air Force logisticians attend the LRO Basic Course. This is a 12-week, in-residence initial skills training course taught at Lackland Air Force Base (AFB), Texas. After graduation from the basic course, LROs are required to cycle through the different functional areas in order to acquire basic, hands-on experience in each area. LROs are required to spend a minimum of one year working in each area. The squadron commander or supervisor decides if the officer has *mastered* the training and then *signs them off* as trained in that functional area. Although some formal courses are available, mainly in the areas of logistics information systems, the vast majority of training is on-the-job (OJT) training. Most of the OJT will be dependent on the officer's initiative and the capabilities of their senior and junior enlisted personnel. At this point, the officer is considered trained and educated in the functional area. This process led one senior Air Force logistician to remark, "I believe the LRO is trained about an inch deep and a mile wide which is ineffective in my opinion."[22] Unit commanders must formally certify, through Base Training, that the LRO has met the minimum criteria for the functional area in question.

Once certified, these LROs are awarded a special experience indicator (SEI) indicating they have completed the requisite OJT in one of three main areas: distribution management, materiel management, and contingency operations. According to the CFETP, "each accession LRO will be required to attain proficiency in each of the three core competencies before attaining the designation of *fully qualified.*"[23] The standard time frame for LROs to reach fully qualified status is anywhere between four to six years of commissioned service time.

The second mandatory Air Force logistics training course is the newly developed LREC course. LREC is a ten-duty-day, in-residence course that is also taught at Lackland AFB, Texas. The purpose of LREC is to provide field grade LROs operational level training with an emphasis on command and control within an expeditionary operations framework. It is designed to prepare LROs for increased responsibility in the logistics readiness squadron (LRS) as well as positions at the Joint and AFFOR levels.[24] The CFETP requires all Air Force logistics majors and major selects to attend LREC.

There are other elective courses provided by various institutions; however, these are unit funded and scheduled training and education events. Units may not have the funding to support the officers' temporary duty to one of these classes. The following is a short list of potential elective classes available to Air Force logisticians.

- Air Force Institute of Technology short courses such as Logistics 199, 299, and 399
- Defense Acquisition University courses
- Contingency Wartime Planning Course

- Various sister Service and Joint courses such as the Joint Course on Logistics (Army) and the Joint Planning Orientation Course (Armed Forces Staff College)

For the purposes of this research, it is enough to know that the courses are available, but they are not mandatory courses required by the Air Force logistics community.

Current Navy Supply Officer Corps Education Program

As you can see in Figure 2, the Navy utilizes three pillars (similar to a Greek Parthenon) to illustrate officer professional development. The pillars are based on officer qualifications, assignments, and education. Unlike the Air Force, the Navy directly emphasizes the performance of the officer as part of his or her overall development track (base support of the pillars). The Air Force implies performance, by providing promotion opportunities and simulating progression through the ranks, but is not as deliberate as the Navy in stressing the need to do one's job well. Ultimately, these pillars support the worldwide placement of naval forces (Parthenon ceiling).

The Navy lacks a designated logistics officer corps; however, the Navy Supply Corps performs many of the same functions (supply, transportation, fuels, and embarkation/debarkation functions) as its Army and Air Force counterparts. The Navy Supply Corps is a highly trained, specialized team of professionals, who perform executive-level duties in financial management, inventory control, physical distribution systems, contracting, computer systems, operations analysis, material logistics, petroleum management, retailing, food services, and other related areas.[25] Upon being commissioned in the Navy and being assigned to the supply corps, officers will attend the Navy Supply Corps School in Athens, Georgia. Unlike the Air Force, Naval officers attend this class before being assigned to their first operational duty. The mission of the school is to train students in the duties of Supply Corps officers afloat and ashore to successfully perform as naval officers in a variety of functions and under a myriad of conditions with credit to themselves, the corps, and the naval service.[26]

Once a student graduates, the officer's first assignment will be at sea. This assignment is not considered natural evolution, but is an opportunity for the officer to perform.[27] Success at sea is similar to successful company command in the Army. If the

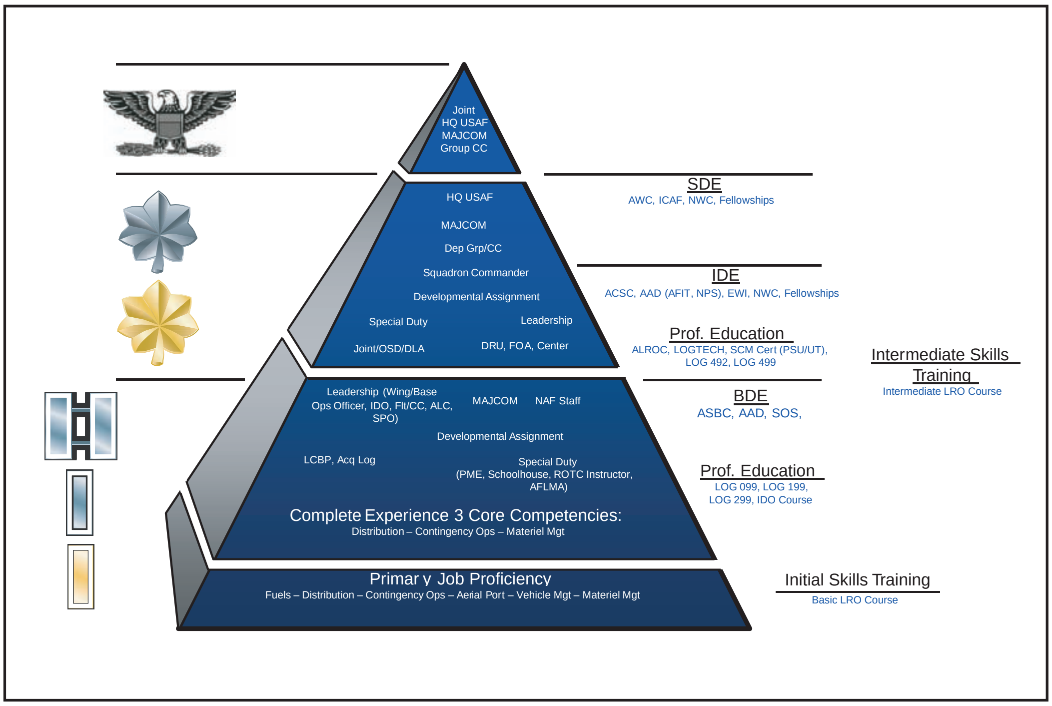

Figure 1. Air Force Logistics Officer Career Pyramid

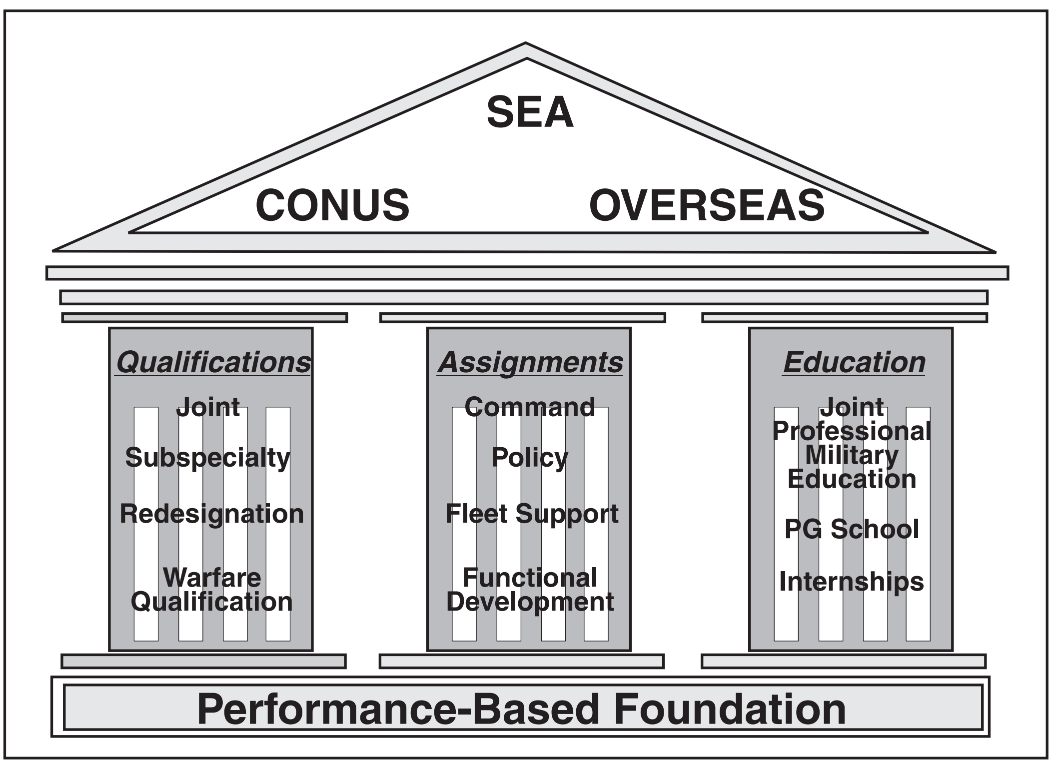

Figure 2 Navy Career Development Components

officer does well, then he or she can expect to be given greater responsibility with each new assignment.

As an officer gains experience, he or she is awarded additional qualification designators (AQD) to mark that experience. The AQDs are similar to the Air Force's SEIs. Unlike the Air Force SEI program, a Navy officer loses proficiency in the AQD if he or she has not worked in that discipline for more than 12 years.[28] Additionally, an officer may be awarded a subspecialty functional code (S-code) that identifies an officer's field of advanced education, functional training, and significant experience. Requirements to earn an S-code vary by subspecialty, but an officer must work in a designated billet from 18 to 24 months to be awarded the S-code.

The Navy has a host of education opportunities to offer its supply officer corps. Figure 3 provides a more detailed view of education opportunities afforded to naval supply officers. Of note are the large numbers of intern programs (80) that are available to officers. These positions are competitively filled, but offer a fantastic opportunity to receive specialized education. Similar to the Air Force, the Navy offers a host of masters degrees in logistics specialties (transportation, supply, fuels) at the Naval Post Graduate School, Monterey, California. The Air Force offers similar programs at the Air Force Institute of Technology, Wright-Patterson AFB, Ohio. Because of funding cuts, these academic degree producing programs have been reduced from a peak of 30 to 40 positions in the late 1990s, to 3 to 4 academic positions annually. Over the course of the review, the Navy Supply Officer corps career field was found to operate very similarly to the Air Force as well as offer many of the same education opportunities available in the Air Force; however, its reverberating verbiage of pride made the Navy stand out from the other Services.

Current Army Quartermaster Officer Education Program

In comparison to Air Force logistician training, the Army first qualifies its logistics officers in branch-specific Basic Officer Leadership Course III (BOLC III) such as Quartermaster, Ordnance, and Transportation. These courses range from 14 weeks for the Quartermaster Basic Course to 19 weeks for the Ordnance Officer Basic Course. The purpose of the course is to provide an educational foundation to serve in any *entry level* position in that field. For example, the purpose of BOLC III for the quartermaster is

> …to train lieutenants on the unique functions performed by quartermaster soldiers. Training focus is on technical supply, materiel management, petroleum, and water functions of quartermaster platoons and an introduction to the general functions of logistics. This focus develops graduates as quartermaster generalists, capable of filling any quartermaster lieutenant position (except aerial delivery positions).[29]

BOLC III is akin to the Air Force logisticians technical school training offered at Lackland AFB, Texas.

At the three- to four-year point captains and captain selects attend the Combined Logistics Captains Career Course (CLC3). CLC3 provides advanced-level training in tactical planning functions and multifunctional logistics skills and can be considered a primer for future assignment to a division or COCOM staff. In accordance with Army Regulation 600-3, *The Army Personnel Development System*, the intent is to prepare Army officers for duties as company commanders and staff officers on multifunctional staffs.[30] The course length is 24 weeks and is divided into four separate phases. This class is taught at the Army Logistics Management College (ALMC) at Fort Lee, Virginia. Phase One is approximately six weeks in duration and is focused on preparing soldiers to command company-sized units. Phase Two of the course is five weeks and trains CGOs in their branch specific critical tasks at a regimental (or branch) school. Phase Three is seven weeks in duration and is focused on training the student in multifunctional logistics. Phase Four is six weeks in duration and is titled the Combined Arms and Services Staff School (CAS3). It trains students in staff procedures, which is similar to the Air Force's Squadron Officers School. This phase is taught at the Command and General Staff College, Fort Leavenworth, Kansas.[31] The Army also provides a Support Operations Course (SOC) to help branch-specific qualified officers transition into the logistics branch.[32] This course is designed to provide critical knowledge to enable officers to lead, plan, and execute sustainment support in small-scale contingencies as well as in a major theater of war. Students learn what doctrine is and how tactics, techniques, and procedures affect their ability to provide logistics in the field. SOC is taught in two phases; the first phase is distance learning and the second is two weeks of classroom training at ALMC, Fort Lee, Virginia.[33]

A variety of functional assignments are identified at the platoon, company, brigade, and battalion level that an officer should strive to fill in order to build a solid foundation for future, increased responsibility. It is similar to the Air Force pyramid previously discussed, but the officer's path is framed

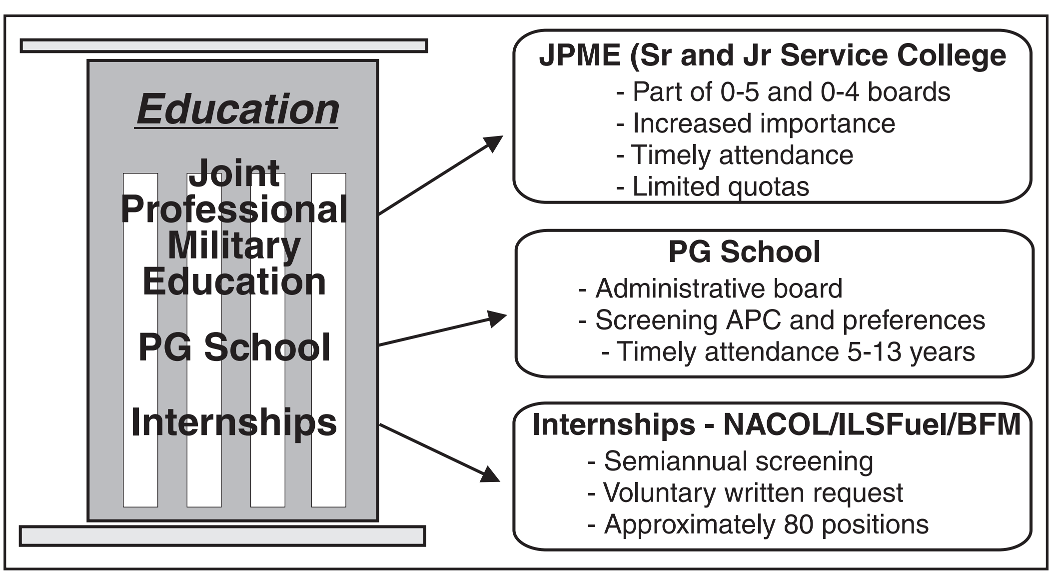

Figure 3: Navy Education Pillar

around education and training versus the Air Force where the focus job types are the centerpiece.

The Army merged its various logistics disciplines in 2008 (similar to what the Air Force accomplished in 2002) as part of its continued transformation to meet the needs of the warfighter in the field. Unlike the Air Force, the Army has a history of providing the necessary education, training, and experiences to deliberately develop officers to meet the various levels of war. This forethought is evident in the education and training opportunities that are continuously offered to officers at all grades.

Observations from Sister Services

As seen in the sister Service comparisons, logistics training and education in the Army and Navy appears to be more regimented and better funded. The biggest concern in Air Force logistics education and training is the eight-year gap between formal education programs (initial technical training as a second lieutenant followed by LREC as a major). The Army and Navy systems take a more holistic approach, scheduling increasingly difficult education and training that builds upon the officer's experiences as he or she progresses. These steps are in line with the Elaboration Theory education model. That is, organizing course structures in a simple to complex sequence which reflect the course's primary focus.[34] Also, the education and training is geared toward developing functional experts who will perform well at all levels of war, but specifically, their educational and training programs address operating at the operational level of war. Within the Air Force, an officer may not be formally prepared for success on a COCOM or AFFOR staff, but he or she may be successful through hard work. As one senior Air Force logistician declared:

> Too much of all of the above happens randomly; if one happens to work in a job where they are exposed to this, then they pick it up, but that's not a very well-designed system to create highly competent O-6 LROs across the board.[35]

Despite differences, all three Services emphasize the need for education and training opportunities. In fact, the Navy appears to offer more formal education programs (masters degrees) than either the Air Force or the Army. This was quite surprising.

Mathematical Model to Determine Senior Officers

The LRO career field is a scant ten years old, but since September 11, 2001, LROs have been in increasingly high demand to fill in lieu of (ILO) taskings and Joint billets. The career field contains approximately 1,725 officers (lieutenant colonel to second lieutenant), but fills 106 365-day temporary duty (TDY) ILO taskings annually.[36] Such a small career field with such heavy and oftentimes competing demands must ensure it is educating and training its future senior leaders to effectively perform at all levels of war. As a mechanism for focusing educational requirements, the author took a top-down approach to determine how many officers would be needed to meet the needs of COCOM and AFFOR staffs.

The mathematical model in Table 1 represents how many Air Force logistics O-6s may be produced from the 2003 year group (identified in the *Generates* column) with either a generalist or specialty core competency. This model begins to fill in the gaps for LRO career field managers to determine how many officers should be selected to become specialists in a particular core competency. The model is robust enough so that the year group population sizes can be easily substituted to determine how many officers should be identified with a particular core competency by year group.

To utilize the model, the author analyzed the 74 LRO O-6 authorizations and determined which authorizations may be classified by functional expertise (critical skill set). Table 2 provides a breakdown of the O-6 authorizations and their corresponding critical skill set. A generalist position denotes the officer does not require a deep understanding of a particular LRO competency to successfully fill this position. LRO O-6 positions that require a more a deep understanding of a particular core competency (materiel management, air transportation, distribution, contingency operations, and fuels) were determined by reviewing the organization that the position is assigned to, the MAJCOM subidentification, and the authorized program element code. The core competencies are identified in the current 2005 LRO CFETP and were validated as being critical requirements during electronic interviews of over 100 senior officers filling LRO O-6 authorizations. The O-6s that responded to the interview identified these core competencies as the most required to successfully perform in their current position.

After matching a core competency against an O-6 authorization, each core competency category was divided by the total number of O-6 authorizations. This product is the

LRO Core Competency	O-6 Job Breakdown	Percentage	Number of Officers from Year Group Matched to Skill	Rounded	Generates
Generalist	43	58	66.82	66	7.06
Material Management	8	11	12.43	12	1.28
Air Transportation	8	11	12.43	11	1.18
Distribution	8	11	12.43	12	1.28
Contingency Operations	6	8	9.32	9	0.96
Fuels	1	1	1.55	5	0.54
Total	74	100	115	115	12
Year Group Population		115			
12.30839564 – Number of officers expected to make O-6 starting with 5 years CYOS 43.5 percent of officers with strategic vector					

Table 1. 2003 Year Group Officers With Five Calendar Years of Service (Forecasting Model Developed by Author)

percentage of O-6 jobs by core competency. The percentage was multiplied by the number of officers in a year group to determine a rough estimate of how many officers from a year group should be identified to fill the particular core competencies. Because there is only one fuels position at the O-6 level, the author rounded the year group percentages for each core competency downward and shifted these fractions to the fuels core competency. This provided a more realistic picture on the number of officers to be identified by year group to follow a fuels education and training path. Thus, this *rounded* number becomes the basis for the formula discussed below. The manual manipulation of the data at this point provides a sense of logic to the outcome of the mathematical model and does not affect the validity of the data generated.

Once the core competency requirements were determined, the author created a formula designed to take an officer year group's population size, multiplied by the career field's retention rate (7-year average) and multiplied by line of the Air Force promotion rates (major, lieutenant colonel, and colonel) to generate the number of O-6s by core competency for that year group as the officer progresses toward 20 years of commissioned service. The retention and promotion rates are Air Force averages and can be substituted in the model if new rates become available. The results of this formula enable career field managers to determine the quantity of officers needed by core competency as well as determine the education and training track (discussed in previous section) to fill logistics officer requirements on the AFFOR and COCOM staffs. The formula used to generate the results listed in Table 1 is outlined in Table 3. Most Air Force O-6s rotate every two years, but with successive year groups ahead and behind the example year group illustrated previously, there should be sufficient officers, by core competency, in the *pipeline* to fill potential O-6 openings regardless of core competency.

Skill Sets	Number of Authorized O-6 Positions Requiring Specialized Skill Set	Percent of O-6 Positions
Generalist	43	58
Material Management	8	11
Air Transportation	8	11
Distribution	8	11
Contingency Operations	6	8
Fuels	1	1
Total	74	100

Table 2. Senior Air Force Logistics Positions (AFPC/DPAPA, 9 February 2008 and Author Developed)

The following is the forecasting formula developed to determine how many officers by year group should be identified with a particular core competency.

= ((((((population x retention rate to reach 8-yrs of CYOS) x O-4 promotion rate) x retention rate to reach 12-yrs of CYOS) x O-5 promotion rate) x retention rate to reach 20-yrs of CYOS) x O-6 promotion rate)

The formula was built into Microsoft's Excel program and the results are provided in Table 1. To verify reliability, the model was *run* 100 times and the results were consistent during each iteration.

Table 3. Forecasting Formula (Developed by Author)

To determine the retention rates of LROs, the author coordinated with the Air Force Personnel Center (AFPC) and obtained the Air Force approved retention rates for the LRO career field (see Table 2).[37] These rates are calculated based on seven years of data. These same retention rates aid in determining the sustainment models generated for each career field. The sustainment models are used to determine accession targets by AFSC, possible force shaping targets, and other *health of the fleet* information.

To calculate the retention rates, AFPC's analysts determine the number of officers that started the year on active duty by commissioned years of service (CYOS). The fraction of officers that completed the year is divided by those that started the year and is expressed as a percentage. This initial data is used to determine the Cumulative Continuation Rate which can be defined as the chance that an officer entering the Service with zero CYOS will complete *X* years of service.[38] For example, as shown in Table 4, there is a 72 percent chance that once an officer reaches five years of commissioned service he or she will continue and complete eight years of commissioned service.

One year's worth of data is not considered statistically viable, thus, seven years of data are used to determine career field trends and provide a better approximation of an officer remaining on active duty. To further illustrate, Figure 4 graphically depicts the life of an LRO year group over a 30-year career. The X axis represents commissioned years and the Y axis represents the population of LROs by percentage. The black line represents the cumulative retention rate for LROs. Thus, Figure 4 graphically depicts how many LROs will be available at a certain commissioned year point. The line is fairly smooth and depicts a natural attrition of officers (retire or separate). This enables senior logistics leaders to focus education and training before the LROs moves into the next level of leadership and ensure enough LROs are on hand to fill critical COCOM and AFFOR positions.

Conclusion and Recommendations

This research indicates that LROs are unprepared to serve at the operational level of war and the Air Force's education and training program should be overhauled to meet the needs of the COCOM and AFFOR staff. Over half of the senior Air Force logistics officer population was interviewed and the results were used to determine how to educate and train Air Force logisticians. As one senior officer stated, "believe we need to identify around the senior captain time frame the LRO track an individual will be going—only way to build our future LRO leaders…"[39] This was the prevailing thought among the interview respondents. The majority of interview respondents believed that an Air Force logistician should follow one of six tracks (generalists, materiel management, air transportation, distribution, contingency operations, and fuels). For the purposes of this research, a track is defined as a specialized career plan that leads to the education and training of an officer to serve as a functional expert. However, before individual officer tracks are identified, it was necessary to determine how many and what type of officer would be placed on that track. A mathematical model was developed that calculated how many officers by year group were needed to be functional experts. The model calculated a pool of officers robust enough to ensure enough officers would be promoted to O-6 and have the right education and training in order to provide advice on time sensitive decisions to COCOM and AFFOR staffs. The right officers, with the right skills should speed up the decisionmaking process and lead to greater unity of effort on the COCOM and AFFOR staffs.

Once functional expert training plans are put in place, a tracking mechanism will need to be developed to keep track of the functional experts. The current Air Force logistics SEIs provide an in-place mechanism to locate officers with functional expertise on demand. It will more than likely fall on AFPC's assignment team to track and monitor LROs identified as functional experts.

Based on the research on which this article is based, the Air Force should identify a set number of logisticians by year group to become functional experts in the five core competencies (material management, air transportation, distribution, contingency operations, or fuels) as well as identify officers to serve in generalists positions. Figure 5 provides an example career path for an LRO who has been identified to become a material management functional expert. The figure flows from left to right. To begin, the officer would enter the Air Force and begin an initial assignment in an LRS. At his or her initial assignment the officer would attend technical training at Lackland AFB, Texas and then master as many competencies as possible during the assignment. The squadron commander would certify the officer in any discipline he or she believes the officer has successfully learned. This will provide the officer with the basic logistics foundations and processes at the base or retail level. Their second assignment carries them into the wholesale world at the depots or logistics support centers. This combines an officer's retail level foundation with a wholesale piece. At this time, the officer may attend a 30-day training course that focuses the officer's education on materiel management as well as provides some Joint and leadership training to prepare them for future challenges. For LROs to truly grasp the operational level of war, they will need an intermediate course that fills in the current gap between lieutenant and major. Additionally, the officer may pick up some acquisition experience. When the officer has completed this assignment, he or she would go back to the base level and serve as the supply chain flight commander (largest LRS flight)—applying wholesale and retail knowledge to improve flight line operations (sortie generation, spares support). The officer would then move to a major command staff or possibly fill a Joint billet at the Defense Logistics Agency. Either job would complement the officer's functional expertise. By this time the officer may attend professional military education or pursue squadron command. After completing the command tour, the officer would move to Headquarters Air Force or possibly the Global Logistics Support Center. This career path aligns the officer to become a future material group commander when he or she is promoted to colonel. This assumes, of course, the officer will accept the guidance and mentorship provided to them by senior officers. Additionally, this path assumes an officer will serve 24 years in the Air Force; however, the model does take into account retention. If the officer did elect to separate or retire, there are other officers following the same path to take his or her place.

Recommendations

In order to build upon the initial qualitative information collected in the interview questions, the author recommends conducting an additional scientific survey to validate the results across the Air Force logistics career field. A standard deviation of 5 percent is desired; however, the survey will need to be distributed to a much larger population. According to the sample size calculator software provided by Creative Research Systems, if a survey is addressed to all 750 Air Force logistics FGOs, then 254 respondents are required to generate a standard deviation of 5 percent.[40] A small standard deviation is desired to demonstrate that the responses were tightly clustered about the mean and not dispersed across a standard bell shape curve. A large standard deviation indicates data scattered across a normal bell curve and can lead to concerns about the validity of the data.[41] Furthermore, this ensures the data collected falls within 2 standard deviations of the mean; thus, the data is considered to be normally distributed along a standard bell curve.[42] Since the data is normally distributed, it is reasonable to surmise that the data generated from the responses would be valid across the entire senior Air Force logistician population (+/- 5 percent).

Commissioned Years of Service	Cumulative Continuation Rate
1-4	87%
5-8	72%
9-12	81%
13-20	58%

Table 4. Retention Rates

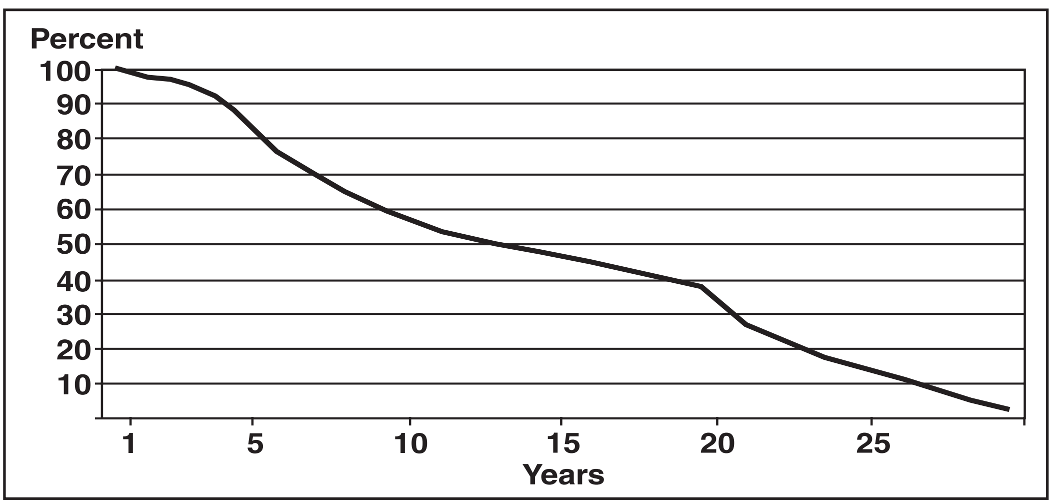

Figure 4. Cumulative Retention Rates for LROs

Rank	Lieutenant	Captain	Major	Lieutenant Colonel	Colonel
PME	ASBC	SOS	SDE	IDE	
Assignment 1	Foundation Assignment in LRS				
Assignment 2		AFMC Depot, LSC			
Assignment 3			Supply Chain Management Flight/CC		
Assignment 4			AFFOR or MAJCOM Staff		
Assignment 5			Joint - Defense Logistics Agency		
Assignment 6				Squadron Command	
Assignment 7				Air Staff or GLSC	
Assignment 8					Materiel Group Commander
Other Education and Training	AFIT 199	Logistics Career Broadening; Supply Chain Management; Degree from UT; AFIT 299	AFIT 399, Certification at UT	AFIT 499, Certification at UT	TBD
Education	Graduate Degree		Certified Professional Logistician		

Figure 5: Material Management Functional Expert Career Path (Author's Depiction)

The functional expert career tracks were limited to the author's own knowledge, his research, and his interview respondents. Further research needs to be performed to determine the proper education and training path to become a functional expert in one of the logistics core competencies. For example, a panel of subject matter experts should be put together for each competency and instructed to *hammer out* a detailed education and training path that deliberately develops officers for the operational level of war. It would enable LROs to have their education spread out over their careers. This would continuously reinforce officer education and allow it to be tailored and focused as the officer progresses. This approach allows the Air Force to develop a credible education and training program to ensure a steady induction of officers into the training and education pipeline, leading to the creation of a continuous stream of logistic subject matter experts prepared to serve at the operational level of war. Ultimately, education would become an enabler to prepare LROs to meet future logistics requirements.

Operation Iraqi Freedom was probably the best example of the United States military's ability to wage Joint, coalition warfare to support the National Security Strategy.[43] Continued success hinges on strong education and training to prepare our logisticians to serve at the operational level of war.

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It will not do to leave a live dragon out of your plans if you live near one.

—John Ronald Reuel Tolkien

Tomorrow's warriors will have to relearn the things that today's warriors have forgotten.

—Gen Billy M. Minter, USAF

Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information on it.

—Samuel Johnson

The society which scorns excellence in plumbing because plumbing is a humble activity, and tolerates shoddiness in philosophy because it is an exalted activity, will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water.

—John W. Gardner

Standardizing Afghan Logistics Training for US and NATO Mentors

Patrick S. Holland, Major, USAF

Introduction

On 1 December 2009 during a speech at the United States Military Academy, President Barack Obama announced he would send 30,000 more troops to Afghanistan as part of the United States' and its international allies' effort to keep pressure on the terror groups.[1] President Obama pointed out "…while we've achieved hard-earned milestones in Iraq, the situation in Afghanistan has deteriorated."[2] Commanders on the ground continued to ask for more troops while the Taliban began controlling certain areas in Afghanistan. The Taliban's ultimate goal has always been to disrupt not only the Afghan government, but the coalition partnerships formed between many countries supporting the war effort.[3]

Under the 30,000 troop increase, United States (US) forces and equipment began deploying in the first part of 2010. Planning is for US and North Atlantic Treaty Organization (NATO) forces to turn over sustainment and security responsibilities to the Afghan National Security Forces (ANSF) by 2011.[4] The 30,000 troops includes Army brigade combat teams as well as military personnel from the Marines, Air Force, and Navy.[5] These additional forces increase the ability of the US and NATO to train their ANSF counterparts by providing the support, time, and security for mentoring operations.

In his speech, President Obama also emphasized that "Our overarching goal remains the same: to disrupt, dismantle, and defeat al-Qaeda in Afghanistan and Pakistan, and to prevent its capacity to threaten America and our allies in the future."[6] To help achieve this goal, President Obama outlined three key elements.

- **Counterinsurgency.** Pursue a military strategy aimed at stopping the Taliban's momentum and increasing Afghanistan's capacity over the next 18 months. The additional troops will target the insurgency and secure key population centers. President Obama also emphasized he would ask for more international military contributions to support the war in Afghanistan.[7]
- **Civilian surge.** Work with the United Nations and the Afghan people in pursuing an effective civilian strategy. The aim here is to reinforce positive actions in addition to working with US allies, international agencies, and the Afghan people.[8]
- **Effective partnerships.** Recognize that success in Afghanistan is linked to our partnership with Pakistan. President Obama highlighted the fact that "…we need a strategy that works on both sides of the border."[9]

President Obama's decision to increase troop levels came after many discussions and meetings with his cabinet to include General Stanley McChrystal, then Commander, US Forces Afghanistan (USFOR-A) and Commander, International Security Assistance Forces (COMISAF), who provided a candid assessment of the situation in Afghanistan. In his unclassified assessment obtained by the Washington Post, General McChrystal reported the situation as "serious" and "the stakes in Afghanistan are high."[10] General McChrystal further stated "success is achievable," but requires a "...significant change to our strategy and the way that we think and operate."[11] The key take-away from his assessment is that NATO's International Security Assistance Forces (ISAF) require a new strategy so that the Afghans will embrace and begin conducting independent operations. Additionally, ISAF needs to grow and improve the effectiveness of ANSF forces by legitimizing its importance to the Afghan government.[12] General McChrystal concluded his assessment by identifying the following recommendations.[13]

- Grow the Afghan National Army (ANA) to a target authorization of 240,000
- Grow and develop the Afghan National Police (ANP) to a total of 160,000
- Realign and streamline the responsibilities of ANSF generation and development
- Provide Combined Security Transition Command-Afghanistan (CSTC-A) direct authority to obligate Afghan security forces funding without passing actions through the Defense Security Cooperation Agency to shorten capabilities procurement timelines and avoid unnecessary fees
- Shift the responsibility and authority for execution of all police training from the Department of State's Bureau of International Narcotics and Law Enforcement to CSTC-A to enhance unity of effort in police development

The purpose of this article is to primarily focus on the third item, realign and streamline the responsibilities of ANSF generation and development, by specifically examining how US and NATO forces are trained to mentor the ANA in logistics operations.

Background

Dictionary.com defines a mentor as, "A wise and trusted counselor or teacher; an influential senior sponsor or supporter."[14]

In Afghanistan, as well as in Iraq and past conflicts such as Vietnam and Korea, mentors have played key roles in helping their foreign counterparts learn how to become self sustained, how to lead, and eventually, how to conduct operations on their own with minimal supervision. The US Army traditionally calls its mentors combat advisors (CA), but the actual name varies depending on the type of mentoring mission a Service member is assigned to perform.[15] A CA's mission is to teach, coach, and mentor his or her host nation security force counterparts so as to accomplish the following.[16]

- Rapidly develop counterparts' leadership capabilities
- Help develop command and control and operational capabilities at every echelon
- Allow direct access to coalition forces' enablers to enhance host nation security force counterinsurgency operations
- Incorporate coalition forces' lethal and nonlethal effects on the battlefield

Figure 1 outlines the various types of mentoring teams supporting Operation Iraqi Freedom and Operation Enduring Freedom (OEF).

Under General McChrystal's recommendation to "realign and streamline the responsibilities of ANSF generation and development," he outlines three subcomponents:[18]

- Combined Security Transition Command-Afghanistan (CSTC-A)/NATO Training Mission-Afghanistan (NTM-A) focuses on ANSF force generation consistent with operational requirements, develops Afghan ministerial and institutional capabilities, and resources the fielded forces.
- Shift responsibility for development of fielded ANSF to the International Security Assistance Force Joint Command (IJC).
- Employ enhanced partnering and mentoring to more rapidly develop Afghan forces.

General McChrystal realized ISAF could not continue operating as it had done in the past and needed a new strategy. This new strategy had to be one that the Afghans would believe in along with being able to sustain ANSF Forces. The strategy also needed to be properly resourced and executed by a civilian-military counterinsurgency campaign. Additionally, the Afghan people had to support this new strategy, otherwise it would not succeed.[19]

General McChrystal also noted ISAF was poorly configured for counterinsurgency operations, did not understand the local language and culture, and struggled with the challenges of being in coalition warfare.[20] To fix the problem, General McChrystal clarified and reorganized ISAF's command relationships for achieving better unity of command and unity of effort. Under the old ISAF organizational structure, each of ISAF's subordinate headquarters had separate campaigns and was not organized effectively.[21]

Figure 2 shows USFOR-A and ISAF's reorganized C2 organizational structure.

In reorganizing ISAF's command relationships, General McChrystal established a new intermediate operational headquarters known as ISAF Joint Command (IJC). Under this construct, ISAF headquarters could focus primarily on strategic and operational issues, while IJC could concentrate on synchronizing operational missions and enhancing civil-military coordination. IJC also became directly responsible for all ANSF mentoring teams with CSTC-A and NTM-A focusing on ANSF institution building, force generation, force sustainment, and leader development.[24] For the US and NATO mentors out in the field, the battlespace owners were now responsible for both mentorship and kinetic operations in their respective areas of

OIF		OEF	
BN MTT	Motorized Transport TT	BNN ETT	Medical Operations ETT
BDE MTT	Logistical and Admin TT	BDE ETT	Garrison Support ETT
DIV MTT	Logistical BN TT	Corps ETT	Air Operations Command ETT
BN Border TT	Medical Operations Advisory TT	CS BN ETT	OTSG Mentor Team
BDE Border TT	AF C-130 Advisory TT	BDE Support ETT	Medical Treatment ETT
REG Border TT	Garrison Support Unit TT	Corps Support ETT	Drill Instructor ETT
BN National Police TT	Regional Support Unit TT	CSS ETT	Class V Depot ETT
BDE National Police TT	Iraqi Ground Forces Command TT	Afghan National Police ETT	Commo Support ETT
DIV National Police TT	NCC Advisory TT	Afghan National Police Regional HQ ETT	Central Workshop ETT
Air Force Military TT	Medical Assistance TT	Afghan National Police Clinic ETT	Validation ETT
MOI TT	MOI Intelligence TT	Forward Support Depot ETT	TAG Augmentee Cell ETT
MOD TT	Iraqi Air Force Support Operations TT	Forward Support Command ETT	BDE Material Afghan National Army Management Office ETT

Figure 1. Mentoring Team Types[17]

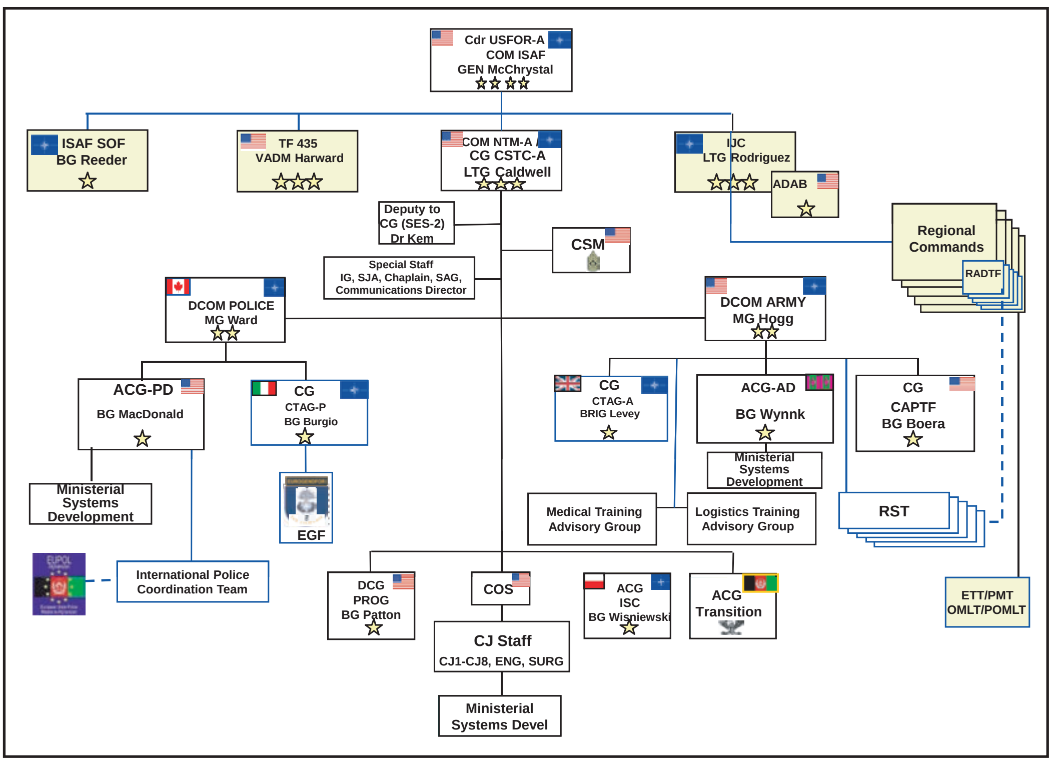

Figure 2. USFOR-A and COMISAF C2 Structure[22 23]

responsibility (AOR) while ensuring everything was synchronized with ISAF's priorities.[25]

During a 365-tour in Afghanistan (July 2008 to July 2009), the author deployed as the Combined Joint Task Force Phoenix (CJTF Phx) Deputy Logistics Director (Dep J4) and later as the ANSF Logistics Cell Chief (ANSF Log Cell). Based on his personal experience, two significant problems came to light in supporting the ANSF logistics mentoring mission. First, predeployment training locations were not providing adequate ANSF logistics training. Second, once the mentoring teams arrived in country, they had to quickly learn the ANSF logistics process while at the same time, mentoring their Afghan counterparts.

In response to these two challenges, Major Mike McPherson, Lieutenant Colonel Lori Strode and Major Pat Holland, developed the *CJTF Phx ANA Logistics Mentor Training Handbook*. Additionally, they created a three-hour block of instruction for mentoring teams in-processing through Camp Phoenix before heading out to their final location.[26] These efforts allowed the mentoring teams to learn about ANSF logistics while giving them the tools needed to become successful mentors. As part of an overall effort to provide future mentors continuity and a foundation for learning about Afghan logistics, the Center for Army's Lessons Learned (CALL) formally published the CJTF Phx handbook as the *ANA Logistics Mentor Training Handbook* on 2 July 2009.[27]

Article Acronyms

ANA – Afghan National Army
ANP – Afghan National Police
ANSF – Afghan National Security Forces
AOR – Area of Responsibility
ARSIC – Afghan Regional Security Integration Command
ARSIC-K – Afghan Regional Security Integration Command-Kabul
AT&L — Acquisition Technology & Logistics
BDE – Brigade
C2 – Command and Control
CA – Combat Advisor
CALL – Center for Army Lessons Learned
CD-ROM – Compact Disk-Read Only Memory
CJTF Phx – Combined Joint Task Force Phoenix
COMISAF – Commander, International Security Assistance Forces
CSS – Combat Service Support
CSTC-A – Combined Security Transition Command-Afghanistan
CSTC-A-LTAG – Combined Security Transition Command—Afghanistan/Logistics Training Advisory Group
ETT – Embedded Training Team
FOB – Forward Operating Base
FSD – Forward Support Depot
HNSF – Host Nation [or Foreign] Security Forces
IJC – International Security Assistance Force Joint Command
ISAF – International Security Assistance Forces
JFTC – Joint Force Training Centre
KMTC – Kabul Military Training Center
LTAG - Logistics Training Advisory Group
METL – Mission Essential Task Listing
MoD – Ministry of Defense
NATO – North Atlantic Treaty Organization
NTM-A – NATO Training Mission-Afghanistan
OEF – Operation Enduring Freedom
OJT – On-the-Job Training
OMLT – Operational Mentor Liaison Team
POI – Program of Instruction
RIP/TOA – Relief in Place/Transfer of Authority
SME – Subject Matter Expert
TTP – Tactics, Techniques, and Procedures
US – United States
USFOR-A – United States Forces – Afghanistan

Research Questions

This article addresses the following questions.

- How are US and NATO mentors being trained on Afghan logistics while ensuring the training received is standardized so that ANSF will one day have a seamless logistics process?
- Where do US and NATO mentors receive their predeployment training and what curriculum is being taught to them?
- How often are the training curriculums updated and what are the primary sources used to update the curriculum?
- What products are available to US and NATO mentors that cover the Afghan logistics process?

Investigative Questions

The author developed interview questions to help guide data collection for the research effort. Interview questions were grouped into two parts. Part I covered questions for either a predeployment training site or an organization responsible for developing or teaching the Afghan logistics processes. Part II targeted mentoring teams and headquarters personnel directly involved in supporting Afghan logistics. The following are the primary questions that were used.

Part I – Predeployment Training Sites or Organization

- What curriculum does your organization teach or develop to help prepare military personnel for their mentoring mission in Afghanistan? Is it possible to obtain a copy of it?
- How often is the curriculum updated in order to keep pace with ongoing operations in Afghanistan?
- Who are your subject matter experts to ensure the curriculum is relevant?
- How many instructors do you have who teach Afghan logistics?
- How often have the instructors deployed and to what locations?
- What other units or organizations have contributed to your curriculum development?
- What products do you offer that cover the Afghan logistics process?

Part II – Mentoring Teams or Headquarters Personnel Involved with Afghan Logistics

- What is your current position or role in supporting Afghan logistics?
- Where did you receive your predeployment training and what curriculum did they teach?
- What branch of Service are you?
- What is your career field?
- How often have you deployed and to what locations?
- How much experience do you have working with Afghan logistics?
- When you arrived in country, what type of training did you receive on Afghan logistics?

Literature Review and Historical Data Search

The author collected key products that served as a baseline for research. Using the CJTF Phx *ANA Logistics Mentor Training Handbook*, the author compared this handbook against the curriculum being taught at the predeployment training sites, as well as the organizations responsible for developing Afghan logistics curriculum.[28] In addition, the author obtained a copy of the *Combat Advisor Handbook* published by CALL and the *Afghanistan Combat Advisor Development Program Course* book used for predeployment training at Fort Riley, Kansas.[29] [30] The author also collected training products from the predeployment training sites.

Assumptions

The author made the following assumptions. They are not necessarily all-inclusive, but highlight the overarching concerns and unknowns.

- The Afghan logistics processes will stay relatively the same despite any reorganization by USFOR-A and NATO's ISAF.
- If given enough time, even though there are ongoing operations in Afghanistan, mentors and headquarters personnel will be able to respond to surveys.
- The CJTF Phx *ANA Logistics Mentor Training Handbook* is adequate enough to serve as a baseline in determining whether Afghan logistics training is standardized.
- Predeployment training sites are teaching the same curriculum to prepare US and NATO forces for the logistics mentoring missions.
- The lack of Afghan logistics training negatively impacts all the Service branches (Army, Navy, Air Force, and Marines) in supporting the mentoring missions.
- Because of the ongoing coalition partnership between the US and NATO, the author will be able to obtain curriculum and information from the operational mentor liaison team (OMLT) mentors.

Limitations of Research

The research focused only on Afghan logistics training and how it affected the ANA.

Methodology

In conducting the research for this article, the author chose a qualitative research approach. According to Leedy and Ormrod, the qualitative research approach is "…typically used to answer questions about the complex nature of phenomena, often with the purpose of describing and understanding the phenomena from the participants' point of view."[31]

Research Design and Data Collection

Using the qualitative approach, the author selected a case study design to drive the research methodology and data collection. The data collected by the author came in a variety of forms such as e-mails, briefings, handbooks, and newspaper articles. In addition to collecting and reviewing key documents, the author conducted phone interviews and e-mailed questionnaires to potential participants. If for some reason the author and participant were unable to conduct an interview, the author accepted e-mail responses and followed up as necessary.

Analysis of Data and Results

Once all of the data was collected, the author organized and presented it in a logical format that helped with categorizing the data, identifying any patterns associated with it, and drawing potential solutions and recommendations. The ultimate goal of the data collection was to distinguish the similarities and differences between what and how US and NATO mentors receive as Afghan logistics training.

Discussion

Based on the research and investigative questions previously outlined, the author e-mailed an interview questionnaire to past and present US logistics mentors, as well as key organizations, that contributed to either building or conducting Afghan logistics training. The author also received briefing slides, training curriculum, and other pertinent information to help provide a clear picture of how training was being conducted for the mentors. A total of 74 requests were sent out to potential participants (28 of the requests were forwarded within Afghanistan to other mentors). Of the 74 e-mail requests, the author received 31 responses back (42 percent response rate). Seven of the 31 responses either assisted the author in identifying other potential participants to send the questionnaire to or declined to participate in the research altogether citing one of the following reasons.

- Person(s) did not think their job or position in Afghanistan was relevant to the research.
- Person(s) had no time to participate in the research because of their daily workload. (Note: This situation applied to both personnel already back home in the US and personnel supporting ongoing operations in Afghanistan.)

In the end, the author had 24 respondents (35.1 percent response rate) who provided valuable insight into how Afghan logistics training was being conducted in preparing US and NATO mentors for their advisory roles. The following is a summary of the major themes and trends for each of the investigative questions. (Note: Due to the similarity of some questions in Parts I and II, the author combined some responses together to eliminate redundancy.)

Part I – Predeployment Training Sites or Organization

1. What curriculum does your organization teach or develop to help prepare military personnel for their mentoring mission in Afghanistan? Is it possible to obtain a copy of the curriculum?

Training curriculum for the Afghan logistics mentoring mission is being developed and taught using a variety of methods and at various organizational levels both in the US and overseas locations. The actual teaching methods employed range from on-the-job (OJT) training once a mentor arrives in country to receiving a formal course taught at either an established training center or power projection platform, such as predeployment training in Fort Polk, Louisiana or Fort Bragg, North Carolina. Table 1 shows the two broad categories training (learning) fall into.[32]

The author identified two primary predeployment training sites used to train US and NATO forces preparing to assume mentoring missions in Afghanistan. The two sites are Fort Polk, Louisiana (formerly Fort Riley, Kansas) and the Joint Force Training Centre (JFTC), Bydgoszcz, Poland. At Fort Polk, the 162[d] Infantry Brigade (BDE) conducts US mentor training for personnel deploying to either Iraq or Afghanistan.[34] The brigade became fully activated in May 2009 and transitioned the CA training mission from Fort Riley to Fort Polk in August 2009.[35]

Fort Polk's training curriculum is based on a combat service support (CSS) construct so mentors will have a better understanding of the CSS functional areas and associated administrative support.[36] The curriculum begins by teaching mentors the US Army logistics system followed by lessons on how to train foreign security forces (FSF) in logistics.[37] Previous research conducted by Captain Joseph Whittington pointed out more CSS familiarization training was needed in predeployment training to properly prepare logistics readiness officers for embedded training team missions.[38] Mentors are taught the six learning objectives along with the associated tasks shown in Table 2.

Even though the program of instruction (POI) focuses on objectives for FSFs in both theaters, Fort Polk does offer specialized Afghan logistics training that is covered throughout the one and one-half days of instruction. The students are usually comprised of both Iraq and Afghan mentors. Because of time constraints, the instructors tailor the class based on the overall majority of mentors deploying to a particular country (Afghanistan). Each mentor also receives a compact disk (CD-ROM) containing Iraq and Afghanistan information and resources for future reference.[40]

Predeployment training for OMLT mentors is conducted slightly differently than the training at Fort Polk. Whereas Fort Polk's training is centered on CSS, the OMLT training focuses on running a garrison support unit. OMLT training is conducted in three phases: National Training Objectives, NATO Centralized Training, and ISAF Aim of Training (theater employment of teams). The author focused on Phase II, NATO Centralized Training, because it is the only phase that contains an Afghan logistics curriculum. Training takes approximately one day and covers the areas shown in Table 3.

2. How often is the curriculum updated in order to keep pace with ongoing operations in Afghanistan?

The original intent of this question was to poll the US and NATO predeployment training sites to determine how current was the Afghan logistics curriculum being taught to mentors. Upon reviewing the responses, it turns out this question also applied to the informal training material being used in the field. Six of the 24 participants responded by providing the statements that follow:

- "Was recently built, but I need to link with NTM-A/CSTC-A or the IJC for currency." (Major, 2-130 IN XO[45])
- "Is updated once a year…. Primary sources used to update the curriculum are the instructor SMEs and the feedback given by the logistics mentors." (Log Coordinator of JFTC, OMLT Section[46])
- "Updated as often as it needs to [be] based on the training mission of KMTC." (CPT, S-4 Advisor to Kabul Military Training Center Group[47])
- "Production of the curriculums moved at a very slow pace. In one year's time I only saw the production and publication of one new logistics manual." (Captain, Senior Advisor to 4[th] Forward Support Depot[48])
- "An effort is made to update the curriculum whenever there is a significant change in material." (Lieutenant Colonel, Chief of Logistics Training Advisory Group Integration Branch[49])
- "Updated regularly with any additional information received from the country as well as feedback received via student questionnaire."(CPT, CA Instructor, 162[d] Infantry Brigade[50])

Learning about Afghan logistics is challenging, but keeping the training curriculum updated is an even harder challenge and requires a coordinated effort between the mentors, their higher headquarters, and the predeployment training locations. The author experienced this challenge first-hand. Within a month after the *CJTF Phx ANA Logistics Mentor Training Handbook* was published, the majority of the command and organizational structures were already out of date. Even though parts of the handbook are outdated, at the time of writing of this article some mentors in Afghanistan were still using it as a source document. This included the predeployment training sites at the 162[d] BDE and JFTC.[51] [52] A US mentor in theater recognized the handbook was outdated, yet stated "…it's still a pretty good document."[53]

3. Who are your subject matter experts (SMEs) to ensure the curriculum is relevant?

This question directly relates to the previous one. In order for mentors and predeployment training sites to maintain an updated curriculum, they need to have a person or resource that can provide the latest information from the field. Responses to the question came from civilian contractors (MPRI, DynCorp), military mentors, and civilian advisors. Three of the eight

Informal	Formal
- On-the-job training - Continuity books - Briefings and slides - Lessons learned - Personnel in-processing in-theater	- Combat skills training, Fort Polk, LA - Joint Force Training Centre, Poland - Kabul Military Training Center, Kabul - Handbooks and lessons learned - Afghan decrees and doctrine

Table 1. Training Categories[33]

responses illustrate both the good and bad of how mentors and organizations are obtaining current information.

- The 162d BDE works hard to establish and maintain POCs within Iraq and Afghanistan, especially the students transitioning through the predeployment training. Fort Polk is regularly updating its curriculum based on student feedback and information received from mentors in country.[54]
- One US mentor spent the past 17 months in Afghanistan working ANSF logistics. Based on his experiences and contacts with other organizations in the AOR, he developed training slides to help other US and NATO mentors within the Kabul Military Training Center.[55]
- The OMLT logistics coordinator had an opposite experience compared to the two previous respondents. His organization, JFTC in Poland, is responsible for providing ANSF logistics training to OMLT mentors before their deployment into Afghanistan. The JFTC relies solely on US SMEs with current experience in country. These SMEs instruct portions of the logistics training, but it is difficult to bring them out of theater. JFTC has had one US logistics mentor who has been working with them since his redeployment back to home station in March 2009.[56] [57]

4. How many instructors do you have who teach Afghan logistics?

The author geared this question toward predeployment training sites. While it is important to have the right number of mentors on the ground, the author focused solely on who from these training sites is teaching Afghan logistics and did not look at the mentor manpower assigned to Afghan logistics training.[58] With regards to JFTC, which relies heavily on US SMEs, usually the AOR can provide at least one US logistics mentor to be an instructor. At the OMLT training session in November 2009, JFTC had three US mentors.[59]

For predeployment training in the US, the 162d BDE has four instructors who teach the CA mission. All of the instructors have experience in Iraq, but not Afghanistan. Prior to the CA training mission moving to Fort Polk, two of the respondents commented that when the one Army captain from Fort Riley, who taught Afghan logistics transferred to a new duty location, she was not replaced and an instructor with Iraqi experience took over the course. Today, the same situation continues at Fort Polk. The key takeaway from respondents' comments is "…had to have someone who's been there and can teach it." Likewise, "How is a person who's never been to Afghanistan going to train others?"[60] [61]

5. How often have the instructors deployed and to what locations?

Responses regarding deployment experience varied from statements such as having "…one rotation or deployment to Afghanistan" to "…advisors with extensive years of service and various past deployments to other countries."[62] [63] Past deployment experiences are good, but an instructor has to have experience working the logistics mentoring mission in Afghanistan, otherwise how is he or she going to train others?[64] This same theme is repeated in investigative question number 12.

6. What other units or organizations have contributed to your curriculum development?

This question is very similar to question number 3. Based on the responses, Figure 3 depicts the units and organizations who have contributed to Afghan logistics training. It is important to note that ANSF forces have a stake in the outcome and should

Enabling Learning Objective	Associated Tasks
Combat Advisor Sustainment	Understand US Army logistics systems
FSF CSS Overview	Understand host nation CSS procedures
Contracting Capabilities/Field Ordering Officer (FOO)	- Understand US contracting guidelines - Understand roles and responsibilities of the FOO - Understand nonstandard sources of supply
Mortuary Affairs (MA)/ Summary Court Martial Officer (SCMO)	Understand what is involved with MA for a small team and how to conduct SCMO duties
RIP/TOA Best Practices	Understand RIP/TOA intent and theater guidelines
Battle Damage Assessment and Repair (BDAR)/ Maintenance	Familiarize team logisticians with the BDAR kit

Table 2. Program of Instruction (POI) Learning Objectives and Tasks for CSS[39]

Functional Area Training	Learning Objectives
ANA Logistics Overview	- ANA logistics doctrine - ANA logistics at different levels - Basic logistics procedures - Role of OMLT in ANA logistics - Facilitator to link to specific unit/situation in respective region
Functional Areas and Logistics Decrees	- Logistics functional areas - Main responsibilities in functional areas - Logistics regulations - MoD decrees on logistics and support
Logistics Planning and Management	- Definition of classes (of supply) 1-9 - Decree 4.0 MoD forms
Logistics Establishment	- Logistics facilities - Establishment of a logistics facility
Logistics Operations	- Transportation operations - Medical operations - Tactical operations - Logistics intelligence operations
TF Phx ANA Logistics Mentor Training Handbook	- Process of logistics reports - Independent sustainment - Assessment of checklists - Soldier and unit logistics training plan - Case study exercise

Table 3. OMLT Functional Area Training[41] [42]

be contributing to their own curriculum development. As one respondent put it, "…the goal of any mentor should be to work themselves out of a job."[65]

7. What products do you offer that cover the Afghan logistics process?

Much like the training categories shown in Table 1, the author identified the products, both formal and informal, used to prepare US and NATO mentors for their deployment to Afghanistan. Some of these products focus exclusively on Afghan logistics processes while other products provide a brief overview of the Afghan mentoring mission along with helpful information, such as cultural awareness and tactics, techniques, and procedures (TTP). The following is a brief description of each product.

Formal:

- ***Combat Advisor Handbook (Tactics, Techniques, and Procedures)***. CALL published this handbook for US Service members attending predeployment training at Fort Riley, Kansas. While the training has moved to Fort Polk, Louisiana, the information is still pertinent and setup so it can be used by mentors deploying to Iraq or Afghanistan.[67]
- ***CJTF PHX ANA Logistics Mentor Training Handbook***. CJTF Phx J4 created this handbook for US and NATO forces conducting the ANSF logistics mission. While the handbook primarily focuses on ANA processes and organization, it also applies to mentors serving in other ANSF roles such as police mentoring, air corps, and commandos.[68]
- **OEF Embedded Training Teams (ETT), *First 100 Days Handbook***. This handbook provides ETT members with key information they will need to know and understand in their first 100 days in country. Items covered are based on theater interviews and redeployment surveys covering the most important topics identified by previous mentors.[69]

Informal:

- ***Afghanistan Combat Advisor Development Program Course* book**. The course book is a compilation of briefing slides, news, and journal articles used to orient and get US Service members thinking about their role as CAs.[70]
- **Logistics Training Advisory Group (LTAG) Course Slides**. These briefings present training on how to order and receive supplies for ANA and ANP. They also outline general accountability requirements for tracking expendable supplies and equipment.[71] LTAG, in conjunction with IJC, is working to coordinate training opportunities for mentors in theater.[72]
- **Kabul Military Training Center's (KMTC) Training Slides**. KMTC's S-4 developed ANA Logistics 101 and 201 slides in order to train KMTC mentors on ANA supply chain procedures.[73] These slides were created based on the mentor's experiences working ANSF logistics for the previous 17 months.
- **162d BDE Combat Advisor CD**. The 162d BDE hands each mentor a CD containing reference material for both Iraq and Afghanistan. The CD also contains valuable information on the Army logistics processes that US mentoring teams will need to know in order to sustain operations (property book, ordering classes of supply).[74]

Part II – Mentoring Teams or Headquarters Personnel Involved with Afghan Logistics

8. What is your current position or role in supporting Afghan logistics?

Of the 24 respondents, 4 were in Afghanistan supporting Afghan logistics. Nineteen respondents had previously served in an ANSF role and had redeployed back to the states. The final respondent has deployment experience in Iraq, but not Afghanistan. Table 4 breaks down the duty titles for each respondent.

9. Where did you receive your predeployment training and what curriculum did they teach?

When it comes to mentors learning and understanding ANSF logistics, the logistics training received ranges from nonexistent or minimal at best, to full-blown blocks of instruction. Of the 24 respondents for this question, 5 out of 12 people who attended predeployment training at either Fort Riley, Kansas or Fort Polk, Louisiana, stated ANSF logistics training was available, but minimal at best.[76] One US mentor summed up his response by saying the "Bottom-line is that none of the folks who went through Fort Riley or Fort Polk received adequate training on the Afghan National Logistics System."[77] The other nine respondents, who attended combat skills training elsewhere—Fort Bragg, North Carolina; Camp Guernsey, Wyoming; or Joint-base MDL (McGuire, Dix, Lakehurst)— identified no Afghan logistics training as part of their overall predeployment training.[78]

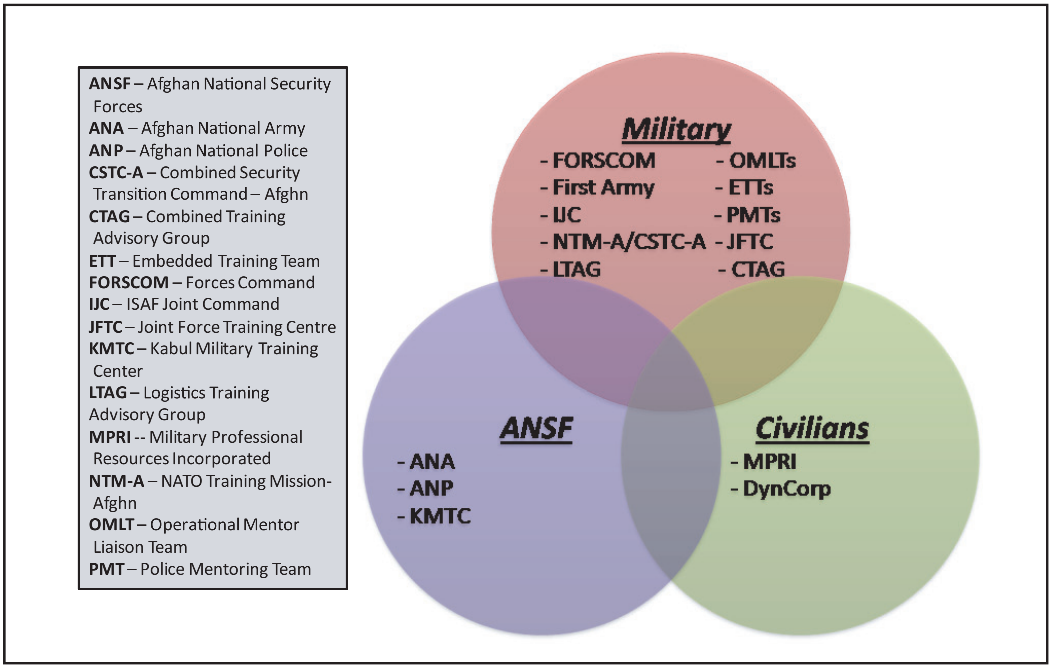

Figure 3. Contributors to ANSF Logistics Training[66]

10. What branch of Service are you? What is your current career field?

Of the 24 participants in this study, 7 were assigned to the Army (5 to Army National Guard), 1 from the Navy, 15 from the Air Force, and 1 from NATO. Although not represented here, US Marines are also filling combat advisory roles in Afghanistan. Table 5 shows the breakdown for each of the respondent's Service branch and career field.

11. How often have you deployed and to what locations? How much experience do you have working with Afghan logistics?

Prior to their Afghanistan deployment, many of the participants had already deployed at least one, if not two or three times, to other locations. Only one respondent stated that he had deployed to Afghanistan previously, but he was not involved in the mentoring mission.[80] These responses were significant because they showed many Service members worked Afghan logistics for the first time. None of the respondents had any prior Afghan logistics experience. After completing their deployment, respondents had anywhere from 6 to 17 months of mentoring experience. One respondent continues to interface with US mentors in order help improve Afghan logistics training. This question was a key finding because it showed that all of the respondents needed some type of training in order to become successful in mentoring Afghan logistics.

12. When you arrived in country, what type of training did you receive on Afghan logistics?

Once US or NATO mentoring teams arrived in country, training continued either in the form of OJT with the outgoing team or teams learned *on the fly* while mentoring their Afghan counterparts. Figure 4 illustrates the types of training US mentors received once they arrived in country.

This graph also shows how the respondents learned to perform his or her roles and does not reflect if the mentor utilized any other training method (CBT, classroom). The author did not examine the number of days spent conducting OJT. This effort would require additional research and was beyond the research scope. However, based on a couple of comments received, the incoming and outgoing mentors spent anywhere from 1 to 10 days of turnover.[82] Four respondents stated they received no Afghan logistics training upon arrival in theater.[83] Four others indicated they were given some type of in-processing training. Again, the amount of time spent ranged from a two-hour overview of Afghan logistics, to a two- or three-day training course led by a contractor.[84]

Findings and Potential Solutions

This section outlines findings and presents potential solutions based on the data collection and analysis. Using the research and investigative questions, the author's goal was to determine if Afghan logistics training is standardized across-the-board between US and NATO mentoring teams.

Findings

1. Afghan logistics training for US and NATO mentors is not standardized.

There is no standardized predeployment training for US and NATO mentor teams. Four main reasons account for this situation. First, US and NATO predeployment training is vastly different from each other and focus the learning material at different levels.

Currently Deployed	Previously Deployed
- Chief, CSTC-A LTAG Integration Branch Consolidated Fielding Center (CFC) S4	- CFC J4 Mentor
- Commando and ANA Special Forces S4	- CJTF Phx Chief of Staff
- Kabul Military Training Center Mentor Group S4 (KMG S4)	- CJTF Phx VII J4
- Senior Mentor, 1st Forward Support Depot	- CJTF Phx VIII J4
	- CJTF Phx J4, ANSF Log Cell Chief
	- CJTF Phx J4, ANSF Log Cell, ANP NCOIC
	- CJTF Phx J4, Contracting and Services Officer
	- CSTC-A Log ETT Integration Chief
	- Commander, Afghanistan Regional Security Integration Command (ARSIC-K)
	- Deputy Commander, 438th Air Advisory Expedition Group
	- Log/Garrison Spt Coordinator for OMLT Trng
	- Regional Police Advisory Cmd XO for Kabul
	- Senior Advisor, ANA Logistics Command, Commanding General
	- Senior Advisor, 1st Forward Support Depot
	- Senior Advisor, 2d Forward Support Depot
	- Senior Advisor, 4th Forward Support Depot
	- Senior Advisor, Forward Spt Group Commander
	- Senior Advisor, Ministry of Defense for AT&L
	- Senior Advisor, Central Workshop
	- Captain, 162d Infantry Brigade

Table 4. Respondents' Positions and Roles in Afghanistan[75]

Career Field	USA	USN	USAF	NATO
Finance and Budget			1	
Force Support			1	
Infantry	2			
Logistics	4		13	1
Personnel	1			
Pilot		1		
Totals	7	1	15	1

Table 5. Branch of Service and Career Field[79]

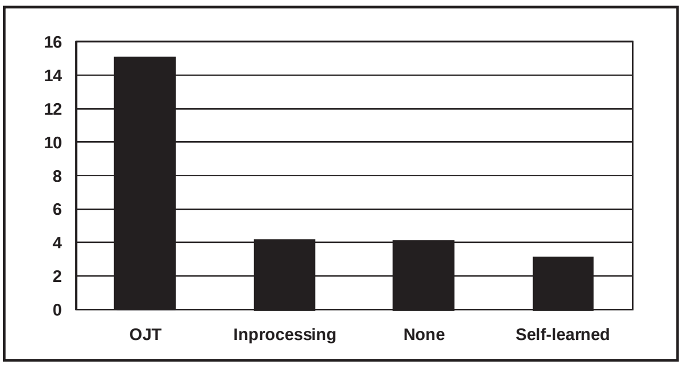

Figure 4. Type of Training[81]

Predeployment training at Fort Polk provides generalized FSF training to both Iraq and Afghanistan mentors at the same time. The 162d BDE instructors try to ensure each mentor understands his or her roles and responsibilities by asking questions and seeking feedback from the students. However, because of time constraints, instructors end up tailoring their lessons based on the majority of mentors deploying to a specific country.[85]

A major problem with the 162d BDE's training structure is that it makes some invalid assumptions. They are as follows:

- **All host nation [or foreign] security forces (HNSF) conduct logistics operations the same way.** While some combat advisory techniques can be applied to both theaters, the specific logistics processes for Iraq and Afghanistan are quite different and unique to each country. For example, Afghan logistics covers both the ANA and ANP. Each has similar processes, but falls under different government ministries with its own set of policies and caveats.[86]
- **Mentors have time, once they get in country, to receive specialized Afghan logistics training.** Figure 4 provided a glimpse of how mentors are learning about their new roles as Afghan logistics mentors. While it is hoped that new mentors will have overlap with the people they are replacing, the training foundation needs to be established at predeployment training sites first. What is occurring in analogous to a person waiting until he or she deploys to receive weapons qualification. Obviously, this would not make any sense, especially if the person is expected to conduct combat operations immediately upon arrival. Why should Afghan logistics mentors be any different?
- **Any combat advisor or instructor can teach HNSF for both Iraq and Afghanistan.** Based on the author's predeployment training experience, this became a problem when students began asking the instructor specific questions, particularly if the instructor had never deployed to Afghanistan. As noted by one respondent, this created a "huge training gap and knowledge with mentors."[87] It also put the burden back on the mentors' shoulders to get needed specific training when they arrive in country.[88]

In contrast to Fort Polk's training, OMLT mentors receive specialized Afghan logistics training during phase two of the JFTC training program. The course material is geared toward the functions they will be required to perform upon arrival in-theater. JFTC's course material is based on information they collected from down range in Afghanistan. The course also has guest lecturers who have Afghan logistics experience. It is also interesting to note that prior to development of OMLT's phase II training course, the JFTC reached out to SMEs from various organizations in order to help them develop a mission essential task listing (METL) for the OMLT mentoring mission. Figure 5 depicts the requirements that went into the METL listing.

There is no centralized standard logistics platform for teaching Afghan logistics.[90] This problem not only existed between US and NATO mentors, but also among other US forces as well. For example, Army National Guard units mobilize and receive their predeployment training at a different location from an active duty Army unit (10th Mountain Division).[91] Even in-theater, this problem still existed when CJTF Phx J4 set up a centralized location to conduct Afghan logistics training. Active duty units reported directly to their forward operating locations and were not required to in-process through Camp Phoenix. OMLT teams reported directly to their final destinations and were not required to in-process through any specific location.

The language barrier between US and NATO mentors and their Afghan counterparts hampered logistics operations.[92] In the 2008-2009 time frame, logistics mentors at the national level developed Afghan Decree 4.0 in English first and then had the documents translated into either Dari or Pashtu, so the Afghans would accept it. The problem mentors soon discovered was that English phrases did not translate well into either language.[93] The Afghans ended up with a document that did not make sense to them. This situation only becomes more complicated when OMLT mentors are added into the equation. Afghans know how to speak some English, but not necessarily German, Albanian, or Dutch. In the end, the Afghans began writing their own documents and then the mentors would have them translated into their own language.[94]

There was a lack of standardization and no emphasis put on Afghan logistics at the corps level.[95] Like US mentoring teams, OMLTs come from different backgrounds and continuity levels. A NATO mentor from JFTC stated "ANSF is confronted with logistics mentors of different NATO and non-NATO nations. Within NATO, there is a logistics guideline, but this info is not available for non-NATO OMLT mentors…"[96] To help compensate for this problem, OMLTs mainly use US logistics doctrine and rely on key products such as the CJTF Phx *ANA Logistics Mentoring Handbook*.[97]

Some US mentors also experience a high turnover rate with their OMLT counterparts, making long-term continuity difficult. Also, adding to the frustration were the unique caveats OMLTs brought with them in-theater. A US mentor gave two examples that highlighted the challenges.[98] First, the Canadians couldn't supply arms [weapons] to their Afghan counterparts without running a background check first. Needless to say, the forward support depot (FSD) stayed full of Canadian equipment because they could not issue items out because of the caveat.[99] Second, British teams came to the FSD looking for supplies and equipment, having the full expectation that the Afghans would be able to provide a full and robust logistics capability.[100]

2. There is a lack of Afghan logistics mentoring experience.

All of the study participants experienced Afghan logistics mentoring for the first time during their deployment in Afghanistan. Out of the 24 respondents, 16 of them were US Navy and Air Force. Based on how Fort Polk's predeployment training is set up, US mentors were not able to get a lot of the specialized training until they arrive in country. Unless Navy and Air Force, mentors have previously deployed with the Army, they must learn a new support system because the Afghan logistics system is modeled after the US Army's system.[101] This automatically puts the mentors at a huge disadvantage and forces them play catch-up with *late-to-need* training.[102] Further, mentors arrived with no baseline or foundation and began advising the Afghans. Depending on the mentor's personality, they either find the right information and answers or form bad habits from the start.[103] US mentors need to show up prepared. The "…we're going to keep doing it the way they've been doing it…."[104] mindset is unacceptable.

3. All mentors, not just team's S-4 (logisticians), need to understand how the Afghan logistics process works.

Afghan logistics training is not something that only the team's S-4 mentor should worry about. Everybody on the team needs an understanding of how the Afghan logistics process works. Otherwise as one mentor put it, "It's like saying only guys in the communication squadron need to know how to use e-mail."[105] This lack of understanding could and does negatively impact operations. For example, an Afghan Regional Security Integration Command (ARSIC) commander wanted to move halal meals to some outlying forward operating bases and had his S-3 plan the mission. When it came time to execute, the ARSIC went to the FSD to get the meals, but did not realize FSD did not have any in stock. To make matters worse, the FSD pointedly explained to the S-3 planner that the meals were long lead time items.[106] From the mentor's standpoint who worked this tasker, the operational side of the ARSIC wanted nothing to do with the logistics and *divorced themselves* from the process.[107]

Part of the reason this situation is happening is that the predeployment sites, such as Fort Polk, have little focus on logistics and primarily focus mentor training on a *shoot, move, communicate* mentality.[108] Also, Fort Polk does not require all of its mentors to attend FSF logistics training. Team leaders are asked to identify who their logistics mentors are so they can attend the training.[109] On the other hand, JFTC has its OMLT training set up to provide an overview of Afghan logistics for all team members and then conducts specialized Afghan logistics training with the designated logistics mentors.[110] The downside to the Fort Polk approach is readily apparent: (1) team members are not prepared to pick up the slack if something happens to the logistics mentor and (2) team members do not understand how Afghan logistics processes can impact their operations.[111]

Disconnects were also seen between the mentors and higher headquarters staff. A US mentor explained it this way: "There was constant tension between CSTC-A staff and mentors. The US plan was not coordinated with the mentors…hence, no 'Afghan face' [solution] to the plan."[112] Also, this mentor was surprised that:

> …staffs were disintegrated and not more integrated after eight years being in country. Pressure from CSTC-A leaders forced time lines on Afghans that were not realistic. [Leadership] tells us to mentor on the decrees, but if it did not meet the US time line, then we were to ignore it.[113]

Another US mentor stated that individuals in higher levels of influence "…have never had to build, create, or assemble an ANSF unit from scratch. And unfortunately, by the time these individuals figure it out, it is time for them to go."[114]

4. No consolidated resource exists for learning about Afghan logistics prior to and during the deployment.

In conducting the research for this article the author collected information from a variety of sources. It became apparent early in this process that no consolidated resource existed for Afghan logistics training. The closest the author got to such a resource was searching through a collaborative lessons learned Web site and then drilling down into the Army's CALL Web site by typing in key words using the search engine. The lessons learned Web site contained a menu sidebar and allowed users to choose lessons learned from the combatant commands, Service branches, and other government agencies.[115]

Having a consolidated resource for Afghan logistics mentoring is important because it allows future mentors to learn from the challenges and issues faced by previous mentors. For individuals who are not familiar with the Army's combat advisory missions (Air Force and Navy filling ETT roles), it gives them a chance to find out a little more about what the mission entails. The 162d BDE Web site did have a "Head Start Center" page that provided suggested readings on Afghan counterinsurgency, Army field manuals, and other resources on becoming a mentor.[116] However, the Web site did not contain any specific resources on Afghan logistics. This same issue was identified in Captain Joseph E. Whittington's research when he identified that there is "no formal mechanism in place" for mentors to share their experiences.[117] One respondent commented that he had a great turnover with the person he was replacing at the FSD, but later missed out on turnover with his inbound replacement because of emergency leave.[118]

Potential Solutions

Afghan logistics training cannot be an afterthought and must be as much of a priority as shoot, move, and communicate training blocks at predeployment training. Based on the findings, there are four potential ways to better standardize Afghan logistics training between US and NATO mentors.

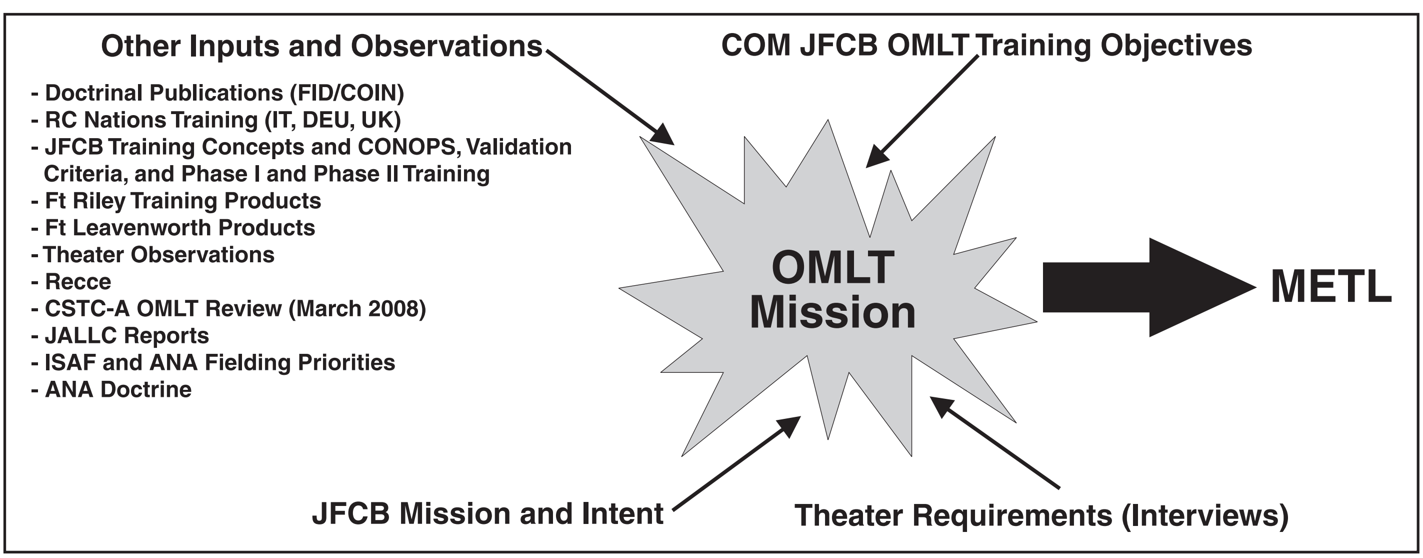

Figure 5. Requirements for OMLT Training[89]

1. Develop a standardized logistics platform for enhancing and teaching Afghan logistics to US and NATO mentors.

First, there needs to be more cross-sharing of training curriculum between the US and NATO predeployment training sites. Both the 162d BDE and JFTC are providing their mentors with the necessary training, but need to ensure they are following the same guidance and baseline in developing Afghan logistics mentors. One way to achieve this is by holding a recurring training conference where US and NATO mentors and training development SMEs come together and outline or discuss how to develop the proper Afghan logistics mentor. The conference could be held in the United States, Poland, or elsewhere. The sponsor could be CSTC-A/NTM's LTAG. LTAG is already responsible for mentor oversight in Afghanistan so it would be the perfect stakeholder to facilitate the event. The downside to this is bringing SMEs out of the field to attend the conference. Also, depending on the OEF operations tempo, conference attendance might be low and would require general officer endorsement to drive home the importance of getting the Afghan logistics mentor training right.

Another idea for cross-sharing information would be for the predeployment training sites to have an instructor exchange program. Instructors from Fort Polk and JFTC would be invited to guest lecture at the other's predeployment training. This would help each training site learn how the information was being presented along with the styles or techniques being used. Students would also gain insight into how their coalition counterparts are mentoring the ANSF along with the challenges they are facing. Because of the coordination involved, extensive planning and agreements would need to be established so that the program continued and did not lose momentum when the programs' points of contact were rotated out.

Second, Afghan logistics mentors should be taught separately from Iraq mentors and provided more specialized training at Fort Polk. Fort Polk's current POI does not give the instructors enough time to teach any in-depth Afghan logistics processes. Additionally, because the focus of the class is based on where the majority of the mentors will be sent, some mentors are under trained. The suggestion to teach Iraq and Afghanistan mentors separately has already been made by 162d BDE's instructors through their chain of command, but has not been implemented.[119] ETTs need to arrive in-theater ready to begin mentoring their Afghan counterparts. The best way to accomplish this task is by laying the foundation at predeployment training.

In order to conduct separate training events for Iraq and Afghan mentors, the 162d BDE could either lengthen the training schedule to accommodate both countries or hire additional instructors so Iraq and Afghanistan classes could be taught at the same time. The biggest drawback would be the manpower cost in either having an instructor teach two different classes or hiring more cadre members. If the 162d BDE hired additional instructors to teach Afghan logistics, it would help legitimize the predeployment training's credibility. The instructors would then be able to adequately address their students' questions and concerns about the upcoming deployment.

2. Invite mentors back to guest lecture at predeployment training and have them provide insights from their deployment experience.

Because Fort Polk's predeployment training currently does not have anyone with Afghan logistics experience, the 162d BDE should consider bringing in recent Afghan logistics mentors to guest lecture on their mentoring experience. One of the responses received was that there is a "…huge training gap and knowledge with mentors."[120] The JFTC has already incorporated deployed mentor lectures into its training program. This has proven beneficial as long as mentors are able to be released from in-theater to attend the training in Poland.[121] The benefit of this approach is that it is one way to augment the manpower required to conduct Afghan logistics training. It would also help enhance the overall training and reinforce the importance of learning Afghan logistics. The negative side to this approach could be that redeployed mentors might not be receptive to guest lecturing because of the personal experiences they had while deployed or lack of interest in participating.

3. Provide all mentors with an overview of Afghan logistics in addition to the specialized training for the designated S-4 mentors.

Just having only the S-4 mentors receive Afghan logistics training is not enough. Every mentor on the team should have an overview of the Afghan logistics process. This overview could be approximately 30 minutes and be incorporated into Fort Polk's in-processing and mission briefings that all personnel receive while attending predeployment training. The overview brief would also help reduce the tension and disconnects felt between mentors in the field and their higher headquarters by providing everyone with a basic understanding of the logistics process. It would also provide operational planners necessary background and situational awareness, both of which are essential in determining the logistics feasibility of potential mission—no more planning a mission and finding out at the last minute it is not logistically feasible. The predeployment training schedule would need to be adjusted to accommodate briefing.

Another option to strongly consider is providing specialized Afghan logistics training for the designated S-4 mentor. This would allow logistics mentors to receive in-depth instruction on the Afghan logistics process. It would also give the logistics mentors time to absorb the material without having to rush through it. The most difficult part of implementing this option is identifying the right person (mentor) to attend training and not just having anyone attend in order to fill the slot.

Additionally, just because a team trains together at Fort Polk does not guarantee they all will stay together upon arrival in Afghanistan. As mentioned earlier, Afghan logistics training is not something that only the team's S-4 mentor should worry about. Everybody on the team needs an understanding of how the Afghan logistics process works.

4. Develop a consolidated Web resources page or pages for Afghan logistics mentors.

Anyone who has ever used an internet search engine (Google, Bing) understands how quickly a person can become overwhelmed with the search results while trying to decipher what information is and is not important. The author experienced this problem first hand in researching ETT lessons learned on the Army's CALL Web site. One way to help speed the process is by adding a Web page to the 162d BDE training site specifically geared towards Afghan logistics mentors. The Web page could contain a bibliography of references pertaining to Afghan logistics as well as briefings and forms that would benefit mentors. It would also be extremely beneficial to have the 162d BDE advertise to all the Services that the Web page exists. Implementing this could be as simple as adding a banner announcement to the main part of the 162d BDE Web page and ensuring all required materials are available.

With regard to CALL's Web site, another idea would be for CALL to add a category specifically dedicated to Iraq and Afghanistan logistics mentors. Mentors would be able to see the latest resources regarding Afghan logistics training and the mentoring mission. They would also have the latest lessons learned already identified at their finger tips. This idea requires discussions with CALL officials to see if it is feasible.

Conclusions and Recommendations

With President Obama's announcement of increasing troop strength, the US and NATO's combat advisory mission will not be going away anytime soon in Afghanistan.[122] Therefore, based on the research, the author recommends implementing the following three recommendations. First, US and NATO forces need to have a standardized platform in place to ensure all logistics mentors receive the right kind of Afghan logistics training. The key to making this happen is to have the predeployment sites, such as 162d BDE at Fort Polk and JFTC in Poland, team-up and cross-share information on a consistent basis.

Second, it is vitally important that US mentors receive as much specialized Afghan logistics training as possible before deploying into the theater. Once mentors arrive in country, it is too late to try and provide the right training while at the same time performing the mentoring mission. This recommendation does not imply mentors should stop learning once they get in country. However, trying to run mentors through a formal training program at that point is much more difficult and late-to-need.

Third, since many Service personnel are experiencing Afghan mentoring for the first time, more emphasis needs to be placed on having all mentors receive an overview on Afghan logistics processes. Also, a consolidated list of resources needs to be established and advertised so that once someone gets selected for a mentoring team deployment, he or she can begin preparing ahead of time. Implementing this could be as simple as adding a resource link on the Army's CALL Web site or Army Knowledge Online and having the other Services' portal pages link back.

In order for the ANSF forces to start taking over sustainment and security responsibilities from the US and NATO by 2011, they need to have a logistics system in place that is standardized and seamless across the entire country.[123] The only way this will happen is if US and NATO forces are following the same guidelines and overarching objectives when mentoring the Afghans on logistics operations. Properly trained US and NATO mentors on Afghan logistics is a critical first step to the overall success of the mentoring process.

Future Research Opportunities

The author recommends conducting future research in the following areas.

- How are the US and NATO forces actually mentoring their Afghan counterparts and what are the end results?

This article focused solely on how US and NATO mentors were being trained in Afghan logistics. The next step is to explore how actual mentoring is being implemented and examine the end results.

- Are there enough US and NATO personnel identified to adequately mentor the Afghan forces? With the increase in additional US forces and the decision to accelerate growth of the ANA and ANP to 240,000 and 160,000 respectively, are there enough personnel identified to support the mentoring mission?[124]

This research would require examining the ANSF development time line while comparing it to the mentors' force flow to see whether or not there is adequate coverage for the mentoring mission.

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60. Author's telephone interview with unnamed Colonel, Senior Advisor to Ministry of Defense, 18 March 2010.
61. Author's telephone interview with unnamed Lieutenant Colonel, Senior Mentor to Central Workshop, 18 March 2010.
62. Log Coordinator of JFTC, e-mail to author, 4 March 2010.
63. Author's interview with unnamed Captain, KMG S-4, "ANSF Log Study," 17 March 2010.
64. Author's telephone interview with unnamed Colonel, Senior Advisor to ANA Logistics Command, Commanding General, 18 March 2010.
65. Author's telephone interview with unnamed Major, Senior Advisor to 2d Forward Support Depot, 8 March 2010.
66. PPT was created by the author to pictorially show all of the contributors to ANSF logistics training based on participants' responses.
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74. Author's telephone interview with unnamed Captain, 162d Infantry Brigade, Fort Polk, Louisiana, 5 April 2010.
75. Information contained in Table 5 is compiled by the author based on participants' responses.
76. Consolidated responses for unnamed Major, Senior Advisor to 2d FSD; unnamed Colonel, Senior Advisor to MoD, AT&L; unnamed Lieutenant Colonel, Senior Advisor for Central Workshop; unnamed Captain, Deputy Commander, 438th AEG; and unnamed Lieutenant Colonel, Chief of LTAG Integration Branch.
77. Unnamed Lieutenant Colonel, Chief of LTAG Integration Branch, e-mail to author, subject: "Follow-up on Research Questions," 22 March 2010.
78. Consolidated responses were compiled by the author based on participants' responses.
79. Information contained in Table 6 was compiled by the author based on participants' responses.
80. Author's telephone interview with unnamed Major, Senior Advisor to 2d Forward Support Depot, 8 March 2010.
81. Information contained in Figure 5 was compiled by the author based on participants' responses.
82. Consolidated responses from First Lieutenant at CFC J4; Major at 1st FSD; and Lieutenant Colonel from Central Workshop.
83. Consolidated responses from Colonel, TF Phx Chief of Staff, OMLT Log Coordinator; Master Sergeant of ANP NCOIC; and Colonel, Former ARSIC-K Commander.
84. Consolidated responses from Major, Senior Advisor to ANA Logistics Command, Commanding General; Major at 2d FSD; Lieutenant Colonel for LTAG Integration Branch; and Major for CJTF Phx VII.
85. Author's interview with unnamed Captain, 162d Infantry Brigade, Fort Polk, Louisiana, 5 April 2010.
86. Based on the author's experience as ANSF Logistics Cell Chief from February 2009 to July 2009.
87. Author's interview with unnamed Lieutenant Colonel, Senior Mentor to Central Workshop, 18 March 2010.
88. Author's interview with unnamed Major, Former Chief of CSTC-A's Integration Branch, 18 March 2010.
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110. Log Coordinator of JFTC, e-mail to author, 4 March 2010..
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Core values make the military what it is; without them, we cannot succeed. They are values that instill confidence, earn lasting respect, and create willing followers. They are the values that anchor resolve in the most difficult situations. They are the values that buttress mental and physical courage when we enter combat. In essence, they are the three pillars of professionalism that provide the foundation for military leadership at every level.

—Sheila E. Widnall, Secretary of the Air Force

I cannot trust a man to control others who cannot control himself.

—Gen Robert E. Lee, CSA

When the political and tactical constraints imposed on air use are extensive and pervasive—and that trend seems more rather than less likely—then gradualism may be perceived as the only option.

—Gen Joseph W. Ralston, USAF

It is the politics of the moment that will dictate what we can do.… If the limits of that consensus mean gradualism, then we're going to have to find a way to deal with a phased air campaign. Efficiency may be second.

—Gen John P. Jumper, USAF

The preeminence of air power will stand or fall not by promises and abstract theories, but, like any other kind of military power, by its relevance to, and ability to secure, political objectives at a cost acceptable to the government of the day.

—Air Vice Marshal Tony Mason, RAF

A Shift in Sustainment Strategy—When Do Vehicles Become Weapon Systems?

John H. Gunselman, Jr, DAF

On 8 July 2009, the Air Force Chief of Staff designated the mine resistant ambush protected (MRAP) vehicle as a weapon system. Security Forces, Office of Special Investigations [OSI], Explosive Ordnance Disposal [EOD] and Tactical Air Control Party [TACP] were issued MRAP vehicles to protect personnel against improvised explosive devices (IEDs). These vehicles are not only armored, but also contain mission equipment that provides positioning, communications, countermeasures, and offensive capabilities. The question now is how to classify the MRAP: Is the MRAP a vehicle or a weapon system? The following article will address this question.

The MRAPs were designed and built by several manufacturers to meet a United States Central Command (USCENTCOM) Joint Urgent Operational Need to protect forces from both under body and side impacting IED detonations. Additional mission equipment to counter IEDs before detonation was developed by the Joint IED Defeat Office. Communications equipment was selected depending on tactics employed, and an armament system was installed. All of this add-on mission equipment was configured and integrated after the vehicle was delivered to the Space and Naval Warfare Systems Command facility in Charleston, South Carolina. Once the equipment was integrated and configured to the applicable vehicle registration number, the vehicle and equipment were shipped separately to an assembly point in the USCENTCOM area of responsibility (AOR).

Upon arrival at the AOR assembly point, the applicable mission equipment was installed and functional users accepted the vehicle. At the point of acceptance, the accountability for the vehicle was established on the expeditionary logistics readiness squadron's (LRS) equipment custodian account, and the mission equipment accountability was recorded on the owning unit's equipment custodian account. Consequently, the MRAP was treated like all other vehicles. Vehicle management within LRS managed and captured scheduled and unscheduled maintenance in the On Line Vehicle Information Management System (OLVIMS) for the vehicle while other organizations performed maintenance on the installed mission equipment. For vehicles, in-commission rates are the current measure of merit. For weapon systems, mission capability is the proper measure. OLVIMS cannot document and track add-on equipment and therefore cannot track mission capability.

OLVIMS was not designed to manage weapon system configurations, so the *as delivered baseline* was captured on an excel spread sheet for each vehicle registration number. Consequently, if maintenance actions were executed against mission systems after the MRAP was placed into service, the true availability of the complete system was not captured in OLVIMS. Additionally, maintenance actions against a piece of mission equipment did not place the vehicle into a deadline for maintenance or parts status because the vehicle was operable in accordance with the OLVIMS status. Because the mission capable status of the MRAP could not be readily determined through the OLVIMS maintenance data collection process, the readiness of the fleet was unknown.

Not only was configuration management a problem (the Air Force has seven MRAP variants with multiple configurations, see Figure 1), but accountability was also a challenge. The vehicle was accounted for on the LRS's vehicle equipment account, while

Article Acronyms

ACC – Air Combat Command
AFCENT – Air Force Central Command
AFEMS – Air Force Equipment Management System
AOR – Area of Responsibility
COMSEC – Communications Security
EOD – Explosive Ordnance Disposal
IED – Improvised Explosive Device
IMDS – Integrated Maintenance Data System
LRS – Logistics Readiness Squadron
MRAP – Mine Resistant Ambush Protected
MSE – Mission Support Equipment
OLVIMS – On Line Vehicle Information Management System
OSI – Office of Special Investigations
POM – Program Objective Memorandum
REMIS – Reliability and Maintainability Information System
SBSS – Standard Base Supply System
TACP – Tactical Air Control Party
USCENTCOM – United States Central Command

the mission equipment was captured on the using organization's equipment and communications security (COMSEC) account. This was problematic for two reasons. First, many pieces of mission equipment were not catalogued and were consequently not picked up on equipment records for worldwide visibility. They were accounted for on local custodian account listings that did not interface with the Air Force Equipment Management System (AFEMS) and they were not visible to the enterprise. Second, the baseline configurations were lost because there was no way to manage a configured weapons system. Each item was managed separately at the item level and not as a complete weapons system at the configuration level (see Figure 2).

Because of the challenges mentioned up to this point, the Air Force Chief of Staff approved designating the MRAP family of vehicles as a weapon system on 8 July 2009, with a start date of 1 October 2010. To meet this direction and to ensure configuration management, accountability for mission equipment, and visibility to the fleet mission capability, the Integrated Maintenance Data System (IMDS) and the Reliability and Maintainability Information System (REMIS) were designated as the information management systems.

Numerous activities have occurred to correctly migrate from vehicle to weapon system management. Air Combat Command (ACC), designated as the lead command, established a weapon system team within the Logistics Readiness Division (A4R) to identify and POM [program objective memorandum] for life-cycle sustainment requirements. Air Force Materiel Command designated Warner Robins Air Logistics Center as the Air Force System Sustainment Manager to manage sustainment and provide configuration control over the seven MRAP variants within the Air Force. Functional managers developed their training, tactics, and procedures for employment of the weapons system and were tasked to determine their enduring requirement.

The next step was to define how to migrate from the vehicle management systems (OLVIMS and AFEMS) to the Air Force aircraft management systems (REMIS and IMDS). First, system requirement designators were assigned and defined the configurations of the seven Air Force MRAP variants by work unit code. This action enabled baseline configurations to be loaded into REMIS. Then ACC and Air Force Central Command (AFCENT) determined an IMDS maintenance data collection concept so maintenance data could be effectively collected. Next,

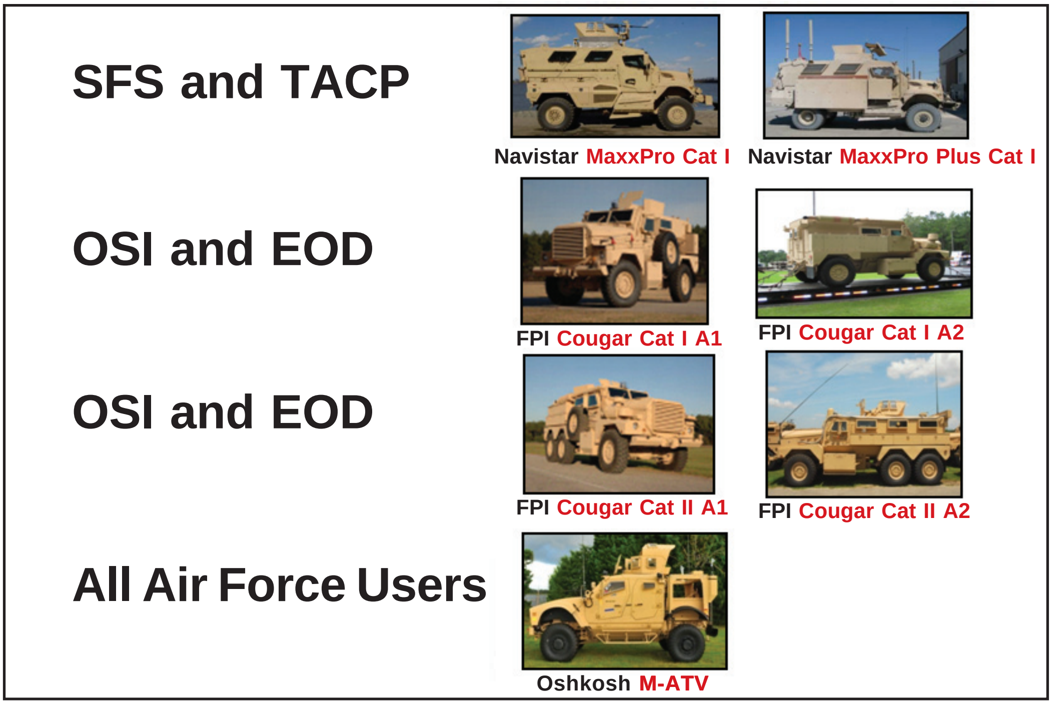

Figure 1. Air Force MRAP Inventory

Figure 2. Current Management Process—Manage the *Eaches*

an implementation schedule was developed to conduct the physical and financial migration from OLVIMS/AFEMS to IMDS/REMIS. Prior to ACC's Beta Test at Moody Air Force Base (AFB), a tabletop exercise was conducted to compare the original configurations received by the government to the current custodial accounts at the base. This exercise identified disconnects prior to the arrival of the transition team at Moody AFB. Upon arrival, Standard Base Supply System [SBSS] transactions were processed to drop the vehicle and installed equipment (not including COMSEC) out of AFEMS. Approved Air Force Form 913, *Aerospace Vehicle Project Action*, MRAPs were loaded into REMIS by registration number. The team assisted the base in gaining the MRAPs from REMIS into IMDS. Each MRAP's configuration was verified by physically inventorying each MRAP by registration number. Mission equipment shortages were identified for resolution. Finally, financial records from AFEMS and REMIS were reconciled to ensure the MRAPs and mission support equipment (MSE) dropped from AFEMS matched the total MRAP value (MRAP + MSE) gained in REMIS (see Figure 3). With lessons learned during the summer 2010 Moody AFB Beta Test, other continental US bases have now begun IMDS implementation.

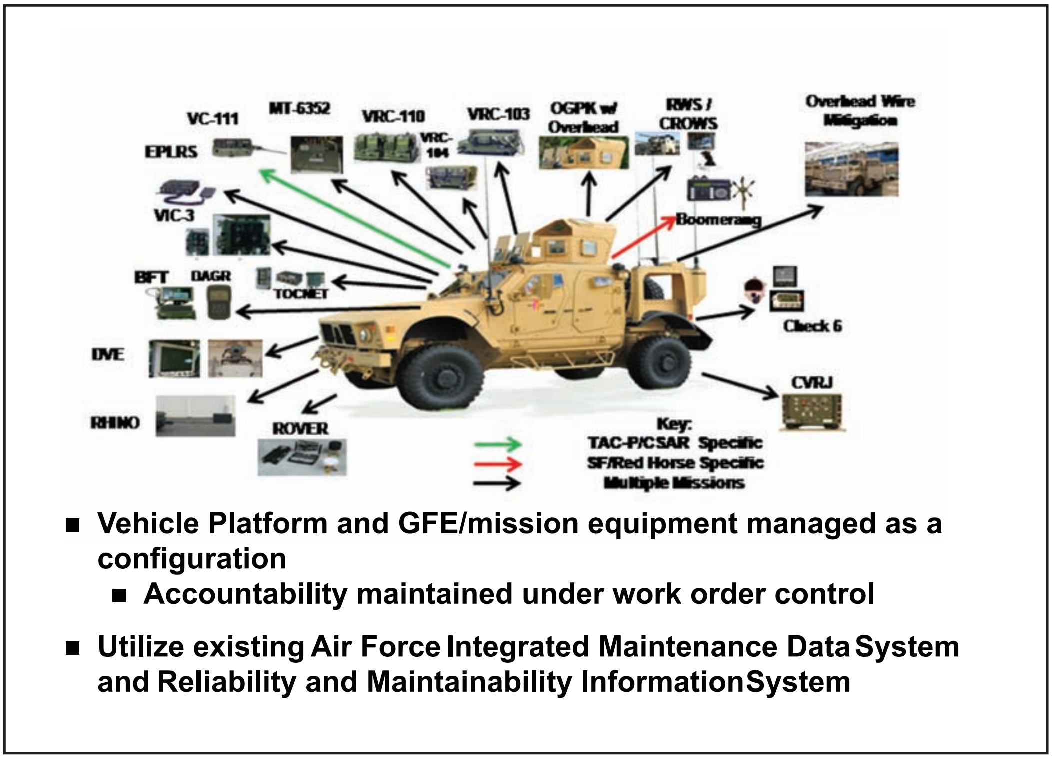

Figure 3. Future Management Process—Manage the Configuration

Shifting the sustainment strategy of the MRAP from a vehicle management concept to a weapon system management concept is no small task. In addition to the cultural paradigm shift across multiple Air Force career fields comes the challenge of defining and codifying processes at every level of the Air Force organization. The next MRAP article will drill into the maintenance data collection concept, which includes organizational responsibilities, process flows, and MRAP management responsibilities.

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One machine can do the work of 50 ordinary men. No machine can do the work of one extraordinary man.

—Elbert G. Hubbard

Our military culture must reward new thinking, innovation and experimentation.… Every dollar of defense spending must meet a single test—it must help us build the decisive power we will need to win the wars of the future.

—George H. W. Bush

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