



Commercial Augmentation for Intelligence Operations *Lessons Learned from the Global War on Terrorism*

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Strategic Model for the Army National Guard Network Transformation

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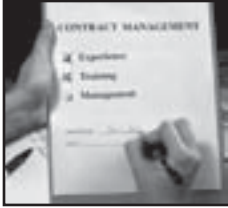
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A NOTE FROM THE EXECUTIVE EDITOR

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COMMERCIAL AUGMENTATION FOR INTELLIGENCE OPERATIONS: LESSONS LEARNED FROM THE GLOBAL WAR ON TERRORISM

MAJ Glenn James Voelz, USA

The enormous operational demands of the Global War on Terrorism (GWOT) have required an unprecedented expansion of private sector augmentation to mitigate critical shortfalls in analytical staffing and supplement operational-level resources for tasks such as collection management, document exploitation, interrogation support, intelligence production, and linguistic services. Unfortunately, few Department of Defense intelligence organizations were fully prepared for the expanded contract administration requirements necessary to manage the influx of private sector support. This article discusses some recent lessons learned from commercial augmentation programs within the Intelligence Community and offers several recommendations for improving the management of these resources.

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BEYOND LEAN AND SIX SIGMA

Maj Joel J. Hagan, USAF, Capt William G. Slack, USMC, Roxanne Zolin and COL John Dillard, USA (Ret)

Aircraft Intermediate Maintenance Division at Naval Air Station Lemoore achieved time and cost reductions using the Naval Air Command Enterprise AIRSpeed program of Lean, Six Sigma, and Theory of Constraints; but, could changes in organization structure or management practices provide further improvements? Organizational simulation software was employed to test interventions that could reduce throughput time for the F414 aircraft engine. A baseline

model was developed and interventions were modeled and simulated. The simulated results indicated that paralleling some tasks could significantly decrease maintenance duration, while maintaining quality. The intervention was implemented saving 26 days per engine. Organizational modeling and simulation can identify and pre-test time and cost savings over and above techniques such as Lean and Six Sigma.

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ON THE ROAD TOWARD CONFIRMING AUGUSTINE'S PREDICTIONS AND HOW TO REVERSE COURSE

Jan P. Muczyk

Military history teaches us that “wonder weapons” are not an adequate substitute for large numbers of simpler but effective counterparts. On the contrary, it teaches us that quantity has its own quality advantages. However, quantity can only be attained by short product development cycles, and that is only achievable if the Department of Defense relies wherever practicable on an evolutionary approach utilizing low-hanging fruit and off-the-shelf commercial components. This article examines not only an evolutionary approach, but also presents counterexamples relying on transformational technology. The final strategy needs to be a well-reasoned combination of both.

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GOVERNMENT CONTRACT BUNDLING: MYTH AND MISTAKEN IDENTITY

Timothy T. Nerenz

The procurement practice of contract bundling is universally regarded as a major barrier to small business participation in federal government contracting. The U.S. Small Business Administration has estimated that 34,221 new bundled contracts were awarded from 1992–2001, transferring \$840 billion of contract revenue from small to large businesses, and causing a 56 percent decline in the number of small businesses contracting with the government. This article summarizes the author's 2006 doctoral dissertation, which tested the validity of those government estimates through analysis of contractor bid protests filed from 1992–2004 with the U.S. Government Accountability Office. The dissertation found that only 25 bid protests were filed by contractors over contract bundling, sharply contradicting the government's estimates of bundling frequency. The dissertation identified the methodological flaw in the government's seminal study on contract bundling that caused overstatement of bundling frequency. The research suggests that contract bundling is in fact a rare and insignificant activity in the government contracting marketplace.

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**TRANSLATED GLOBAL POSITIONING SYSTEM
RANGE SYSTEM TRADE STUDY**

***Kyle Holdmeyer, Paul J. Componation, Alisha D. Youngblood, and
Sampson E. Gholston***

The Translated Global Positioning Systems Range System (TGRS) is currently in production and is being used at most relevant Department of Defense missile ranges. The Enhanced-Translated Global Positioning System Range System (E-TGRS) was ultimately designed and prototypes built to replace the TGRS. However, the E-TGRS was cancelled due to budget constraints. In light of these events, the purpose of the trade study presented in this article is to recommend selection of one alternative based on the comparison of benefits and cost of three alternatives: continue with TGRS as is, perform upgrades to TGRS, or reinstate E-TGRS to replace TGRS.

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**STRATEGIC MODEL FOR THE ARMY NATIONAL GUARD
NETWORK TRANSFORMATION**

LTC (P) Robert E. Banks (TxARNG) and Maj Clayton Duncan, USAF

Defense acquisition policy directs all participants in the acquisition system to recognize the reality of fiscal constraints and to view cost as an independent variable. By direction, “Milestone Decision Authorities (MDAs) are to identify the total costs of ownership and, at a minimum, the major drivers of total ownership costs.” This article describes an Information Technology (IT) Modernization Strategic Driver Model, applies it to the modernization efforts of Army National Guard (ARNG) Joint Force Headquarters (JFHQ) Wide Area Network (WAN), and analyzes the model’s impact on accomplishing defense acquisition system policy objectives. The article establishes and supports that a properly developed strategic model permits decision makers to align acquisition program and technical planning to strategic drivers.

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DEFENSE ARJ EXECUTIVE EDITOR



Welcome to the *Defense Acquisition Review Journal* (ARJ) Issue 46. Our first article in this issue is “Commercial Augmentation for Intelligence Operations: Lessons Learned from the Global War On Terrorism,” by MAJ Glenn James Voelz, USA. The author identifies a number of lessons learned from commercial augmentation programs within the DoD Intelligence Community. The unprecedented operational demand of the Global War on Terrorism (GWOT) placed significant strain on a limited number of contracting officials and required a huge expansion of contracted private sector support to offset critical shortages of various intelligence services in the DoD. Defense intelligence organizations were, in general, not prepared for the dramatic increase in demand for intelligence operations. Some lessons learned discussed in this article deal with these issues: performance of out-of-scope activities, improper use of personal services contracts, inadequate oversight and record keeping, inappropriate contract-award procedures, misuse of Blanket Purchase Agreements, inadequate market research, and poorly defined Statement of Work (SOW)/task order language. Also, there was inadequate training for staff responsible for overseeing contractors resulting in a lack of knowledge of contracting basics.

The following article, “Beyond Lean and Six Sigma” by Maj Joel Hagan, USAF; Capt William Slack, USMC; Roxanne Zolin; and COL John Dillard, USA (Ret), deals with production efficiency from an organizational perspective. This article examines how the use of organizational modeling and simulation techniques reduced the F-414 maintenance time at Naval Air Station (NAS) Lemoore Aircraft Intermediate Maintenance Detachment (AIMD). The AIMD personnel have aggressively pursued reducing aircraft engine maintenance time using the established tools of the NAVAIR Enterprise AirSpeed program. This program seeks to achieve cost/time reductions by using Theory of Constraints (TOC), Lean, and Six Sigma techniques. Furthermore, the authors discuss how a new predictive modeling technique (computational organizational modeling) was used at AIMD Lemoore to add a new dimension of efficiency when applied appropriately in parallel to other minimization techniques mentioned above. Organizational modeling does not focus on the production process, but instead on organizational structure and the information flow through that organization.

The third article, “On the Road Toward Confirming Augustine’s Predictions and How to Reverse Course,” by Dr. Jan Muczyk, examines the validity of Norman Augustine’s predictions about future costs of acquiring high-tech weapon systems. Augustine, former CEO of Lockheed Martin and senior Pentagon official, asserted that in the future, the entire defense budget will purchase just one aircraft, and the military services would have to take turns flying it. The author explains why weapon systems are so expensive today. For example, persistent Cold War mentality of military leaders may lead to the pursuit of transformational technologies, such as those used in the F-22 program or the B-2 program, to solve our problems. There is no question that these systems have pushed technology to a new level during their extended developments, but at what cost? If we continue to pursue technological breakthroughs to counter major military threats, we will quickly reach a point where we can no longer sustain this effort. Expensive systems with advanced state-of-the-art technologies, lengthy development times, and huge support costs are generally not affordable and simply cannot be the only solution. Even with a diminished Cold War threat, the GWOT and the asymmetric nature of future warfare make our challenges much more difficult in a resource-constrained environment. Dr. Muczyk asserts that we must use a combination of acquisition strategies to shorten product development cycle times and take advantage of technological improvements.

The fourth article, “Government Contract Bundling: Myth and Mistaken Identity,” by Timothy Nerenz, discusses a government purchasing strategy called contract bundling. This specific procurement practice combines two or more requirements previously purchased under separate small business contracts into one large consolidated contract that can be unsuitable for small business due to size, geographic disbursement, or specialized capabilities and capacity. Conventional wisdom supported the Small Business Administration’s (SBA) position that contract bundling is detrimental to small business because these large contracts are generally unacceptable to them for various reasons. Testimony from the U.S. Senate (Committee on Small Business and Entrepreneurship) also agreed with the SBA assertion that contract bundling has forced over half the small businesses in the United States out of the \$300 billion federal government-contracting marketplace. This article summarizes the author’s doctoral dissertation, which challenged this generally accepted theory. Mr. Nerenz theorized that the government estimates of contract bundling were overstated, and his research clearly supported this hypothesis.

In the next article, “Translated Global Positioning System Range System Trade Study,” Kyle Holdmeyer, Paul Compton, Alisha Youngblood, and Sampson Gholston summarize a trade study used to evaluate three alternatives regarding life-cycle support of the Translated Global Positioning System Range System (TGRS). The TGRS is part of a compatible family of equipment designed to provide Time-Space-Position Information for participants in DoD test, training, and operational ranges. The engineering design for TGRS is based on 10-year-old technology resulting in questionable capability to meet future deployment needs. An improved system is needed to provide more efficiency and flexibility with better performance and lower costs. In addition, many parts of the current TGRS are becoming obsolete, which may eventually lead to more problems. An “Enhanced” Translated Global

Positioning System Range System (E-TGRS) was developed and prototypes were built, but E-TGRS was recently cancelled due to budget constraints. This trade study considered three alternatives: to continue with TGRS as is (maintain status quo), to implement upgrades to TGRS, or to restart E-TGRS (to replace current TGRS). The trade study recommended the third alternative—continuing with current TGRS while restarting E-TGRS development and testing. With no serious developmental issues, E-TGRS production could begin at the end of FY 2008.

The last article, “Strategic Model for the Army National Guard Network Transformation,” by LTC (P) Robert Banks, (TxARNG), and Maj Clayton Duncan, USAF, explores how an Information Technology (IT) Modernization Strategic Driver Model can be applied to the modernization efforts of Army Reserve National Guard (ARNG) Joint Force Headquarters (JFHQ) Wide Area Network (WAN). The authors then analyze the model’s impact on accomplishing defense acquisition system policy objectives. The model shows that IT operational core factors can align with strategic goals and permit decision makers to integrate the acquisition program and technical planning to strategic drivers.

Dr. Paul Alfieri
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COMMERCIAL AUGMENTATION FOR INTELLIGENCE OPERATIONS: LESSONS LEARNED FROM THE GLOBAL WAR ON TERRORISM

MAJ Glenn James Voelz, USA

The enormous operational demands of the Global War on Terrorism (GWOT) have required an unprecedented expansion of private sector augmentation to mitigate critical shortfalls in analytical staffing and supplement operational-level resources for tasks such as collection management, document exploitation, interrogation support, intelligence production, and linguistic services. Unfortunately, few Department of Defense intelligence organizations were fully prepared for the expanded contract administration requirements necessary to manage the influx of private sector support. This article discusses some recent lessons learned from commercial augmentation programs within the Intelligence Community and offers several recommendations for improving the management of these resources.

Since the beginning of the Global War on Terrorism (GWOT), the Department of Defense (DoD) has witnessed an unprecedented expansion of private sector support to military operations, a market now valued at over \$200 billion a year and accounting for nearly half of the DoD's total annual expenditures (Apgar & Keane, 2004, p. 45). Equally significant has been the dramatic increase in service-based contracting. During the mid-1980s, approximately two-thirds of the Pentagon's acquisition budget went towards the purchase of goods and infrastructure projects while today over half of all DoD contracting dollars are used to acquire services, representing a 90% increase since 1993 (Makinson, 2004).

For many decades, DoD employed contract labor primarily for logistical and military support functions. Today, the private contractor workforce is used extensively for sensitive security- and intelligence-related tasks as well. Among several of the intelligence organizations created in the wake of 9/11, such as the National Counterterrorism Center (NCTC) and DoD's Counterintelligence Field Activity (CIFA), more than half of all staff analysts are private contractors (Pincus, 2006). This trend applies as well for many of DoD's deployed operational organizations with over 60 firms currently providing security and intelligence-related services in Iraq and 20 in Afghanistan (Cooper, 2004, p. 570). This figure includes over 6,000 private contract linguists supporting various military operations around the world at a total annual cost exceeding \$250 million (Alexander, 2004). According to some

The most critical element of any successful program of commercial augmentation is the application of effective administration procedures beginning with the contract award.

estimates, nearly half of the entire U.S. intelligence budget in 2004 was spent on such procurements of commercial systems and operational support services (Shorrock, 2005), reflecting DoD's "unprecedented reliance on the contracting community for analytical staffing, workforce management, and training," according to one intelligence community expert (Pincus, 2006).

While these commercial augmentation programs have proven essential for conducting critical wartime intelligence operations, several recent government investigations have revealed deficiencies in contract administration procedures such as repeated violations of the Federal Acquisition Regulation (FAR), misuse of the Federal Supply Schedule, significant performance of out-of-scope activities by contractors, improper use of personal services contracts, and inadequate oversight of contract delivery and performance. A 2004 DoD Inspector General (IG) report reviewing contract awards for the Iraq Coalition Provisional Authority, including several vendors providing intelligence support services, found "significant weaknesses" in management procedures for 22 of the 24 contracts reviewed (DoD, Office of the IG, Report No. D-2004-057, March 18, 2004, p. 28). Likewise, one Government Accountability Office (GAO) report on intelligence support services in Iraq revealed "a lack of effective management controls" in 10 of 11 task orders worth a total of \$66 million (U.S. GAO Study, GAO-05-201, April, 2005, p. 7). These reports, among others, reveal inadequate contract administration recordkeeping for intelligence support services used during recent contingency operations. While DoD intelligence organizations have aggressively exploited a wide range of commercial augmentation to satisfy expanded operational requirements, they have not dedicated sufficient resources and training to ensure the effective management and oversight of these contracts.

THE CONTRACT AWARD PROCESS

The most critical element of any successful program of commercial augmentation is the application of effective administration procedures beginning with the contract award. This process includes the tasks of identifying requirements, circulating requests for proposal, soliciting bids, conducting market research, and developing contract language. Shortfalls in any step of the development process can make effective management and surveillance of contract performance difficult, if not impossible, to achieve.

The enormous operational demands since 9/11 have placed many DoD intelligence organizations under significant pressure to rapidly expand their collection and analytical capabilities, in some cases resulting in inappropriate modification of contract award procedures. One of the problems cited in recent investigations was repeated misuse of Blanket Purchase Agreements (BPA) under the General Services Administration (GSA) Federal Supply Schedule to expedite contract awards and bypass open bidding. These violations of Federal Acquisition Regulation (FAR) were later cited by investigators as contributing factors in problems with contractor support in Iraq and at the detention facility at Guantanamo Bay for operations involving human intelligence teams, document exploitation support, strategic debriefing, linguistic services, and interrogation functions (Department of Interior IG Report, 2004).

Generally speaking, such BPAs offer the government a simplified contracting vehicle whereby an agency may use an indefinite delivery order for a broad class of goods or services where the precise quantity and delivery requirements are not known in advance. These contract vehicles are particularly useful for repeated procurements of individual services over a given period of time, particularly from habitual service providers offering a known price advantage with an established record of performance. When properly applied, this system can greatly expedite the process of solicitation and market research, yet problems with several intelligence-related contracts arose when contracting officials misused GSA schedule labor categories to acquire out-of-scope services for certain intelligence support activities. Specifically, GSA schedules used to procure strategic debriefers, interrogators, counterintelligence agents, and intelligence analysts for work in Iraq were classified as “engineering” and “information technology services.” A later GAO review of these contract awards found that “the labor category descriptions in the GSA contracts were, in most cases, significantly different from the descriptions on DoD’s Statements of Work and do not accurately represent the work the contractor performed” (U.S. GAO Study, GAO-05-201, 2005, p. 8).

A drawback of using such BPA awards for sensitive intelligence functions arises partly because with the GSA system the government loses a significant degree of oversight into how a vendor may fulfill an individual task order. This situation can also limit the government’s discretion over the screening, vetting, and assignment of contractor personnel. Additionally, GSA procedures provide limited visibility into how a prime contractor may subcontract out various parts of the required services. For routine commercial services, this arrangement is generally satisfactory, yet is problematic as contracting officers attempt to provide appropriately suited individuals

for highly technical intelligence tasks or sensitive operational requirements. The Army investigation into abuse incidents at Abu Ghraib specifically cited the potential danger of using the GSA Federal Supply Schedule for sensitive intelligence activities, noting that such “contracts should be carefully scrutinized given the complexity and sensitivity connected to interrogation operations” (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 50).

In addition to misapplication of GSA schedules, several contracts for intelligence-related services in Iraq and Guantanamo Bay lacked sufficient market research and utilized improper solicitation procedures. Expedited awards for several support contracts with the Coalition Provisional Authority in Iraq included problems with vague requirements language, improper use of personal services contracts, and lack of price reasonableness determinations prior to award (DoD, Office of the IG, Report No. D-2004-057, March 18, 2004, p. 18). Other procedural irregularities surfaced during reviews of interrogation support contracts for the Abu Ghraib detention facility including evidence that vendors assisted in the drafting of the requirements language and preparation of Statements of Work (SOW) prior to the contract award. While there are some legal allowances for such collaboration, the subsequent contract award to the same vendor potentially presented a conflict of interest in violation of FAR guidelines (DoD, Office of the IG, AR 15-6, Abu Ghraib, 2004, p. 49).

Many of the cited discrepancies in the contract award process were attributable in part to enormous unforeseen operational demands of the GWOT. This operation placed significant strain on a limited number of contracting officials, some without adequate knowledge of the unique mission requirements or specific tasks that the vendors would perform. The Army in particular was unprepared for the surge in demand of intelligence support requirements for GWOT operations. During the initial phases of Operation Enduring Freedom (OEF), numerous intelligence organizations reported critical shortfalls of key personnel, particularly for high-demand skills sets such as linguistic support and interrogation operations. A U.S. Central Command after-action review of OEF operations reported that “the Army could not provide, and did not have an effective system in place to identify and contract for this support” (U.S. Army Central Command, Operation Enduring Freedom: CAAT Initial Impressions Report, p. 54).

DEVELOPING CONTRACT LANGUAGE

Another significant shortfall affecting some intelligence service contracting has been the lack of standardized contract language and explicit SOWs describing the nature of required support. A recent GAO report on DoD contract management procedures noted that there has been “no standardization of necessary contract language for deployment of contractors” (U.S. GAO Study, GAO-03-695, June 2003, p. 3). Such problems have led to some contract personnel arriving at duty locations with insufficient training, equipment, or professional qualifications for their assigned tasks—a problem compounded by task orders inaccurately describing the nature of

services to be performed and conditions of the work environment. One contracting official involved with Operation Iraqi Freedom (OIF) noted, “the demands that we asked of our contractors were not always written in the contracts that they were supporting” (Tiron, 2003, p. 32).

The mismatch between SOW language and required contractor skill sets was cited as a compounding factor in difficulties with management of interrogators supporting OIF. The initial SOW for contract interrogation services described similar skill sets as military occupational specialty 97E, Human Intelligence Collector, yet many of the contractor personnel were later determined to lack equivalent professional

Difficulties in developing precise SOW language often arise from a lack of communication between the contracting authority and the end user of the commercial service.

training as their uniformed counterparts. Several of the contractors in question possessed experience in law enforcement or related civilian functions but lacked specific knowledge of military interrogation techniques, the Law of Land Warfare, the Geneva Conventions, and applicable DoD intelligence oversight policy (DoD, Detainee Operations Inspection, 2004, p. 88). Similar problems were identified during operations in Afghanistan where several contract interrogators supporting operations at Bagram Air Base had received no military intelligence training prior to deployment.

Another implication of poorly defined SOW language is that narrowly articulated duty descriptions can significantly limit the range of labor that a contractor may perform as mission requirements change over time. A Contracting Officer’s Representative (COR) is legally unable to revise SOW language based on changing mission needs without an explicit revision to the original contract. In some cases, this situation results in undue pressure on contractors to perform out-of-scope activities for which they are not properly trained. In the case of Abu Ghraib, several of the contractors performing interrogation and analytical functions were originally employed only for translation services. The Army investigation recommended that for future operational support contracts, the “requiring activities must carefully develop the applicable SOW to include technical requirements and requisite personnel qualifications, experience, and training” (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 49).

Another issue of concern arising from narrowly crafted contract language is that when task orders do not reflect the actual nature of work to be performed, pressure often arises from the vendor’s local manager to “grow the contract” outside of the scope of the original proposal. This situation may result in operational inefficiencies for the receiving unit as well as potentially unforeseen costs to the government, as contracts must be modified after the fact to reflect the actual conditions of work performance.

Difficulties in developing precise SOW language often arise from a lack of communication between the contracting authority and the end user of the commercial service. In the case of the OIF interrogation contracts, the original SOW did not specify the need for prior training in military interrogation procedures, detainee handling policy, or applicable military intelligence doctrine. In some cases the contracting authority did not possess familiarity with the specific mission needs of the receiving unit or the manner in which contractors would be employed, resulting in the deployment of contractors not properly screened or qualified for their required duties.

For sensitive functions such as intelligence collection and analysis, it is imperative that language in the contract proposal explicitly define all performance standards and technical qualifications. This requires that contracting officers without operational intelligence experience must have close interaction with technical experts from the requiring unit and frequent interface with designated CORs located at the site of work; yet, in many cases this level of collaboration does not occur. The GAO report on management procedures in Iraq found that contracting officers “had little to no communication with the CORs in Iraq and did not follow up to obtain monthly reports from them on the contractor’s performance ... [and] never verified that the Army personnel serving as CORs had appropriate training” (U.S. GAO Study, GAO-05-201, 2005, p. 12).

Communication between the contracting officer, the requiring unit, and the designated CORs must begin at the earliest stages of the Request for Proposal process to facilitate effective market research, identify the most suitable vendors, and ensure that appropriate contract language is developed that reflects actual mission requirements. Without input from the requiring unit, it is nearly impossible for contracting officers to communicate clear performance expectations to potential vendors during the solicitation process. As a review of intelligence operations during OIF concluded, the “continued use of contractors will be required, but contracts must clearly specify the technical requirements and personnel qualifications, experience, and training needed (Independent Panel to Review DoD Detention Operations, Final Report, 2004, p. 69).

CONTRACTOR TRAINING AND INTEGRATION

Detailed SOW language is also a necessary prerequisite for ensuring proper vetting, pre-deployment preparation, and integration of contracted support. The Army’s Abu Ghraib investigation noted that 35 percent of the contract interrogators originally employed at Abu Ghraib lacked experience as interrogators, and none had received training on Geneva Conventions or rules of engagement for treatment of detainees (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 51). The lack of pre-deployment training placed contract personnel “at a higher risk of violating Army policies and doctrine, and decreasing intelligence yield” to the support units (DoD, *Detainee Operations Inspection*, 2004, p. 87). Furthermore, military supervisors in receiving units generally had little or no control over the vetting and pre-deployment process for arriving contractors and “knew little of their

[contractors'] individual backgrounds or experience and relied on higher headquarters to screen them before arrival. Such screening was not occurring" (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 40). The Army determined that the subsequent integration of these contractors without proper training and certification "created ineffective interrogation teams and the potential for non-compliance with doctrine and applicable laws" (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 18).

Recent policy changes outlining a revised selection process, training, and certification have addressed some of these early problems with contractor integration.

Similar pre-screening problems were also cited in the review of the initial operations at the detention facility in Guantanamo Bay. Many of the contract linguists supporting the intelligence operations had no experience with military interrogation techniques or intelligence methodologies. Although contract linguists were vetted for basic language proficiency, some of their skills sets were not appropriately matched against required duties for interrogators as the operational demands became more specific and mission requirements evolved.

Recent policy changes outlining a revised selection process, training, and certification have addressed some of these early problems with contractor integration. Currently, all DoD contract interrogators must have previously received some training on military interrogation techniques or possess equivalent educational or professional experience. Furthermore, all contract interrogators must now receive training on approved interrogation procedures, Geneva-Hague Convention, and Law of Land Warfare, and are subject to extraterritorial jurisdiction for any violations of procedures occurring in the performance of their duties (Kimmons, 2006).

In addition to pre-deployment training, contract personnel involved with intelligence support services must also be pre-screened to determine eligibility for necessary security clearances. During recent operations, some deployed contractors holding only interim clearances were unable to serve in assigned duty functions while awaiting final clearance adjudication, a situation resulting in wasted government resources and work backlogs for the supported unit. This problem was partly attributable to unmonitored vendors who did not adequately pre-screen their employees, resulting in deployed personnel unable to pass the required background checks. During the initial phases of operations in Afghanistan and Iraq approximately 30–40 percent of linguist candidates provided by DoD vendors never received final clearances for work on intelligence-related missions (Voelz, 2006, p. 76). Recent rules changes to the DFARS now stipulate that "all required security and background checks be complete and acceptable" prior to deployment, but given the enormous backlog of background investigations this requirement still presents an enormous

challenge for contracting officers as they try to project support estimates for rapidly changing mission requirements (DFARS, 48 C.F.R. Pt. 252.225-7040 (h), 2004).

To effectively utilize such commercial augmentation, contracting authorities must have a clear understanding of the operational environment, mission objectives, special skills, clearance requirements, and the pre-deployment training expectations of the supported unit. These details must be clearly outlined in the initial Request for Proposal and explicitly articulated in the SOW language so vendors are able to pre-screen personnel best suited for the mission requirements. Finally, contract language must clearly provide the government with a mechanism to remove and replace any contractor that does not meet the performance expectations established in the SOW.

MANAGING CONTRACTOR PERSONNEL

One of the major challenges of utilizing commercial augmentation for intelligence operations arises from the generally poor understanding of contract management procedures among military commanders. A GAO review of Army contract management procedures during recent operations noted generally “inadequate training for staff responsible for overseeing contractors and limited awareness by many field commanders of all contractor activities taking place in their area of operations” (U.S. GAO Study, GAO-03-695, 2003, Executive Summary). A separate report on management procedures for intelligence support in Iraq found that “the Army officials responsible for overseeing the contractor, for the most part, lacked knowledge of contracting issues and were not aware of their basic duties and responsibilities” (U.S. GAO Study, GAO-05-201, 2005, p. 1).

“There is no specifically identified force structure nor detailed policy on how to establish contractor management oversight within an AOR . . .”

Part of the challenge in preparing military leaders for contract management responsibilities is exemplified by guidelines provided in the Army’s own doctrinal manual, noting that “there is no specifically identified force structure nor detailed policy on how to establish contractor management oversight within an AOR [area of responsibility]. Consolidated contractor management is the goal, but reality is that it has been, and continues to be, accomplished through a rather convoluted system” (U.S. Army Field Manual (FM) 3-100, 2003). Existing doctrinal guidelines for managing deployed contractors were described by one recent GAO report as “inconsistent and sometimes incomplete” (U.S. GAO Study, GAO-03-695, 2003, p. 1). An independent investigation of OIF interrogation operations reinforced this finding, noting that “oversight of contractor personnel and activities was not sufficient to ensure intelligence

operations fell within the law and the authorized chain of command” (Independent Panel to Review DoD Detention Operations, Final Report, 2004, p. 69).

While ample doctrinal literature exists on general contract management procedures, there is virtually no guidance that specifically deals with the unique oversight challenges of managing commercial intelligence services. The Abu Ghraib investigations noted that “no doctrine exists to guide interrogators and their intelligence leaders in the contract management or command and control of contractors in a wartime environment” (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 49). The report also pointed out that during recent operations the “interrogators, analysts, and leaders were unprepared for the arrival of contract interrogators and had no training to fall back on in the management, control, and discipline of these personnel” (Abu Ghraib, 2004, p. 49).

In addition to a lack of clear doctrinal standards there is also significant confusion among some military supervisors concerning their responsibilities and legal authorities over contract personnel. Recent investigations revealed that intelligence “leaders faced numerous issues involving contract management ... with respect to contractors; roles, relationships, and responsibilities of contract linguists and contract interrogators with military personnel; and the methods of disciplining contractor personnel” (Abu Ghraib, 2004, p. 18). In many cases leaders unfamiliar with their management obligations will defer these responsibilities to a vendor’s on-site manager for matters such as performance evaluation, discipline, and oversight requirements—a situation that essentially amounts to vendors providing their own management and evaluation.

CONTRACTING OFFICER’S REPRESENTATIVE TRAINING

Perhaps the most important tool for achieving effective oversight of commercial services is the Contracting Officer’s Representative (COR), providing on-site surveillance of the contractor’s work. Yet, critical shortages of DoD intelligence personnel have resulted in the lack of formal training in contract administration procedures for many organizational CORs, who in some cases do not serve in close proximity to the site of work performance. Given the habitual shortfalls in training resources, these CORs are often required to learn their skills through “on the job training”; but as the Abu Ghraib investigation noted, “if functions such as these [intelligence] are being contracted, MI [military intelligence] personnel need to have at least a basic level of contract training so they can protect the Army’s interests” (Abu Ghraib, 2004, p. 51).

A sampling of several ongoing operational support missions suggests a wide variance in procedures and training standards for CORs managing intelligence support contracts. This is due in part to the fact that the specific training requirements for CORs are only vaguely defined by the Defense Federal Acquisition Regulation Supplement (DFARS), and typically established internally by individual government department or agency. For example, during the first 18 months of operations at the joint detention facility in Guantanamo Bay, no assigned on-site government COR

was monitoring contract performance for the linguist and interrogation support personnel (Voelz, 2006, p. 78). The Army investigation of Abu Ghraib revealed similar problems with CORs operating at different locations from the contractor's work, noting that "it is very difficult, if not impossible, to effectively administer a contract when the COR is not on site" (DoD, Office of the IG, AR 15-6 Investigation, Abu Ghraib, 2004, p. 52). A separate investigation into DoD's contract management procedures also determined that "personnel acting as CORs did not, for the most part, have the requisite training and were unaware of the scope of their duties and responsibilities" (U.S. GAO Study, GAO-05-201, 2005, p. 18).

Another challenge for inexperienced CORs is defining clear performance measures and effective surveillance methodologies to evaluate a vendor's work.

Few deployed DoD intelligence organizations have the dedicated resources for long-term oversight by a single individual. Instead, COR responsibilities are often assigned to intelligence specialists as "additional duty" to be performed adjunct to their primary leadership, analytical, or collection management tasks. Frequent rotations of intelligence personnel only exacerbate the challenge of providing continuity of surveillance. Frequently, when a new COR arrives on site, there remains only limited documentary evidence of the vendor's previous work that can provide a useful basis for comparative analysis. Commonly, the vendor's site manager will be the only individual with lengthy operational experience at a given location. All of these factors make it extremely difficult for intelligence specialists without specific contract management experience to effectively fulfill their responsibilities as CORs.

Another challenge for inexperienced CORs is defining clear performance measures and effective surveillance methodologies to evaluate a vendor's work. For many major DoD contracts, dedicated personnel from the Defense Contract Management Agency (DCMA) will oversee a vendor's performance, but these personnel are in critically short supply. Over the past decade, DoD has reduced acquisition management personnel by nearly half while simultaneously more than doubling services contracting (Barr, 2005). As a result, most contracts for operational intelligence support services will be monitored by organizational CORs, in many cases with only limited training in contract surveillance techniques.

Compounding this challenge for inexperienced CORs, few service contracts offer detailed metrics for evaluation of a contractor's performance. SOWs for intelligence and linguistic services will often contain initial qualification criteria, but typically not provide any instruction for skills maintenance programs, developmental training, or periodic reevaluation. Most of the criteria for work evaluation are informal at best

with little consideration given to developmental counseling or periodic performance review. These tasks are generally left to the vendor's on-site contract manager, but often occur without sufficient government surveillance.

The difficulty of defining effective evaluation metrics has become even more challenging as the government moves toward greater use of Performance-Based Service Acquisition (PBSA). This contracting methodology focuses less on specific process description and more on results-based evaluation where the requiring activity defines specific performance goals, known as a Statement of Objectives, then provides vendors with significant latitude in developing work plans to satisfy the government's needs. The benefit of this approach is that vendors are not bound by a specific SOW description and are free to devise optimal solutions for satisfying the government's needs. DoD has established a goal to award 50% of all acquisition dollars utilizing PBSA methodology by FY 2005 (Bolton, 2004).

While most current operational support contracts for intelligence-related activities still employ traditional SOW methodology in which specific labor functions are clear, still somewhat uncertain is how PBSA may be applied for future intelligence support contracts. Although PBSA has clear advantages of leveraging vendor expertise to develop creative solutions to satisfy government needs, this system also places a much greater burden on contracting officers to clearly define mission objectives, conduct careful market research for appropriate vendors, closely manage performance, and evaluate standards of work against the achievement of broad mission objectives. PBSA only increases the necessity of well-trained intelligence professionals closely monitoring and evaluating the contractor's contribution to the overall mission goals. Present deficiencies in contract surveillance practices leave considerable doubt as to the government's ability to adequately utilize these management concepts for sensitive intelligence-related functions, particularly given current shortages of government contracting officers familiar with PBSA methodology (Phillips, 2004). Certainly, even fewer intelligence specialists possess the necessary experience and training to employ these complex management methodologies.

RECOMMENDATIONS

Given that few intelligence specialists possess extensive contract management experience, arming them with general "rules of thumb" is critical in assisting them to make appropriate determinations on the uses of commercial augmentation within their organizations. Due to the sensitive nature of many intelligence support functions, careful consideration must be given to the suitability of private sector augmentation so that public interest is adequately protected. These criteria are not intended as definitive guidelines for validating the applicability of all commercial augmentation programs, but rather serve to highlight some fundamental considerations for effective integration and management of commercial services. These "rules of thumb" offer evaluative criteria in three critical areas: acceptability of private sector involvement, suitability of vendor services, and accountability of contract management procedures.

LEADER "RULES OF THUMB" FOR DETERMINING THE APPLICABILITY OF COMMERCIAL AUGMENTATION FOR INTELLIGENCE SUPPORT SERVICES

Acceptability of Private Sector Involvement

- Contract service does not perform inherently governmental functions.
- Contract administration adheres to proper solicitation and award procedures.
- Use of commercial services does not present operational or intelligence security risks.
- Vendor offers a best value alternative (including price and performance standards).

Suitability of Vendor Services

- Vendor offers unique services or products unavailable in the public sector.
- Vendor offers scalability of service and flexible output to meet mission requirements.
- Contract is negotiated in a mature market environment with in-sector competition.
- Bidder possesses established performance record and known reliability.

Accountability of Contract Management Procedures

- Contract language provides appropriate legal oversight and accountability measures.
- Contract has detailed Statement of Work (SOW) and qualification requirements.
- Contract provides effective contractor integration and training plan.
- Contract offers clear performance measures and evaluation methodology.
- Government possesses appropriately trained on-site contract management personnel.

The enormous intelligence demands of the Global War on Terrorism will require continued reliance on commercial augmentation to satisfy operational requirements. Specialized vendors continue to provide critical skills and services that are not sufficiently resourced within the Intelligence Community and cannot be acquired through traditional government hiring practices. Yet, contract management functions are still not viewed as a core competency among intelligence professionals and frequently misunderstood or neglected by community leaders.

As demonstrated in the preceding discussion, shortcomings in any aspect of the contract management process may lead to poor integration of commercial services, ineffective oversight, and compromise of government interest. For private sector resources to be effectively leveraged by the Intelligence Community, leaders and acquisition specialists must cooperate to improve management practices and provide adequate training and resources to ensure effective oversight of these highly sensitive commercial services.

DISCLAIMER

The views expressed in the article are the author's and do not reflect the official policy or position of the Department of Defense or the U.S. Government.



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BEYOND LEAN AND SIX SIGMA

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Aircraft Intermediate Maintenance Division at Naval Air Station Lemoore achieved time and cost reductions using the Naval Air Command Enterprise *AIRSpeed* program of Lean, Six Sigma, and Theory of Constraints; but, could changes in organization structure or management practices provide further improvements? Organizational simulation software was employed to test interventions that could reduce throughput time for the F414 aircraft engine. A baseline model was developed and interventions were modeled and simulated. The simulated results indicated that paralleling some tasks could significantly decrease maintenance duration, while maintaining quality. The intervention was implemented saving 26 days per engine. Organizational modeling and simulation can identify and pre-test time and cost savings over and above techniques such as Lean and Six Sigma.

The Naval Air Station Lemoore Aircraft Intermediate Maintenance Division (NAS Lemoore AIMD) at Lemoore, California, has worked aggressively to reduce engine maintenance time using the tools of the Naval Air Command (NAVAIR) Enterprise *AIRSpeed* program. *AIRSpeed* is an umbrella program of the Naval Aviation Readiness Integrated Improvement Program (NAVRIP), enabling cost-wise readiness across the naval aviation enterprise (Naval Air Forces Public Affairs Office, 2006). AIMD Lemoore has achieved time and cost reductions at the maintenance activity level using *AIRSpeed*'s prescribed tools of Theory of Constraints (TOC), Lean, and Six Sigma; but, could further improvements be made by changing the organization structure or management practices?

In an effort to answer this research question, AIMD Lemoore teamed with the Graduate School of Business and Public Policy at the Naval Postgraduate School (NPS) to explore organizational modeling as a method for identifying potential

modifications to the organization, which may improve AIMD performance. Specifically, AIMD leadership focused on improving F414 aircraft engine maintenance by decreasing engine throughput duration.

The objective of this effort was to provide the NAS Lemoore AIMD 400 Division, the Division responsible for F414 maintenance, with recommendations on how their organization may be restructured in order to decrease F414 maintenance cycle time. To meet this objective, NPS developed an organizational model of the 400 Division, which described their current F414 maintenance process. This model was then modified to characterize the impact of organizational changes on maintenance cycle time.

This article is organized into four sections. The first, a literature search, provides a basis for understanding organizational modeling in general and techniques specific to the POWER software developed by Dr. Raymond E. Levitt's Virtual Design Team (VDT) research group at Stanford University and employed in this project. The second section discusses the methodology for conducting this study. The third section presents the results of the modeling effort. Finally, the fourth section presents project conclusions, recommendations for restructuring the 400 Division, and recommendations for future research.

COMPUTATIONAL ORGANIZATIONAL MODELING

At the turn of the 21st Century, computational organizational modeling, a new predictive modeling technique, has come of age as a tool that has the potential for helping to assess how changes to an organization may or may not benefit the organization's performance (Levitt, 2004). Computational organizational modeling as a tool for improving quality is different from many other quality improvement techniques such as Lean, TOC, or Six Sigma in that it does not focus on the production process, but instead on the organizational structure that manages that production process, and the information flow through that organization necessary to execute the production process. It is based upon the understanding that by improving the quality of the organization and the flow of information through that organization, the quality of the organization's output can be improved.

The technique of organizational modeling is analogous to modeling employed in the natural sciences such as finite element modeling (FEM) or computational fluid dynamics (CFD) modeling. FEM and CFD modeling both break down the larger structure being modeled into smaller elements, with each element having its own characteristics, e.g., modulus of elasticity, density, or viscosity. With an understanding of how these elements interact, the overall effect of a force on the larger structure can be assessed. Similarly, organizational modeling is accomplished by breaking down an organization into smaller elements such as tasks, people, and communication methods, each with their own characteristics, e.g., time required to accomplish a task, worker experience, communication clarity, and predicting how changes to an organization may affect each element and subsequently how those elements in turn affect the overall organizational performance (Levitt, 2004).

This detailed level of organizational characterization theoretically allows managers to design their organization in the same way that engineers design bridges. Organizational modeling allows managers to perform “what-if” analyses, evaluating, in a virtual environment, the effects of organizational constructs in order to identify the structure resulting in the best output. Gaining similar insight without the aid of a modeling tool would be prohibitive. Organizations could not withstand the dynamics of change after change simply to determine what works best and what does not.

The organizational model employed in this project is POWER, version 1.1.6. It was developed by Dr. Raymond Levitt as part of a suite of Virtual Design Team (VDT) simulations at Stanford University.

VIRTUAL DESIGN TEAM–POWER

POWER evolved from the Virtual Design Team simulations, which are based on macro-contingency theory and describe work in terms of information flow (Thomsen, Kunz, Levitt & Nass, 1998). POWER is based on the premise that no matter what business an organization is in, be it production of widgets, design of skyscrapers, or providing hotel rooms, one thing they all have in common is they must process information effectively to do their job well (Kunz, 1998).

THEORETICAL BASIS FOR POWER

The concept that organizations can be modeled in terms of information flow is based on J.R. Galbraith’s theory of information processing. According to Galbraith, information transfer and processing is dynamic. Due to the complexity and the sheer amount of information, there are often instances when individuals are unable to process all of the information they are given because they do not have the skill or experience to make decisions quickly enough. As a result, an *exception*, as Galbraith defines it, is created. Exceptions are common in today’s fast-paced world in which we are inundated with requests from e-mail, cell phones, Blackberries, etc. In Galbraith’s view, organizations are modeled primarily as hierarchies, and it’s through these hierarchies that exceptions are passed up the “chain of command” to be handled by more experienced individuals. Along with the hierarchical structure by which exceptions are passed, Galbraith notes there are also exchanges of information between individuals at equal level in an organization. These information exchanges can also be used to handle exceptions, and are often more effective than those moving up the chain of command since they tend to overload upper-level managers and create additional exceptions less often (Thomsen, Kunz, Levitt, & Nass, 1998).

METHODOLOGY

Site visits to the NAS Lemoore were conducted consisting of multiple interviews with 400 Division personnel. Information was collected to properly structure the 400 Division model in POWER and accurately characterize the properties of each software

element. Through these exchanges, a baseline model was created that accurately characterized the operation of the 400 Division F414 maintenance process.

Modifications, also termed “interventions,” having potential for decreasing F414 maintenance throughput were identified. Each intervention was separately modeled by modifying the baseline model. Comparisons between the modified and baseline models were made to determine the utility of each intervention. Finally, a combined intervention model was developed incorporating all individual interventions deemed beneficial and compared to the baseline model.

Figure 1 presents the baseline model of the 400 Division. The slanted boxes at the top of the figure represent meetings. The human-shaped symbols represent positions within the Division. The boxes in the center of the figure represent the primary F414 maintenance tasks, while the boxes vertically aligned on the left represent the off-core tasks. The remaining polygons represent milestones in the maintenance process.

The positions modeled were those that directly impacted F414 maintenance. Positions were modeled in terms of the number of personnel assigned, amount of time available to work F414 tasks, qualifications, skill levels, and experience. The time available was modeled as one-sixth of the actual time available since this model considered one of the six engines for which the Division was staffed to conduct maintenance. In addition, off-core tasks described below were added to a position’s workload to occupy the incumbent’s time when not conducting F414 maintenance. Figure 2 presents the organizational structure.

The terminology used in Figure 2 and throughout this report to reference individuals and groups is consistent with terminology used in the Navy’s AIMD. For clarity, these terms are defined as follows:

- Div-0: Division Officer
- PC Officer: Production Control Officer
- AZ: administrative personnel
- 41V: personnel who directly conduct F414 maintenance
- 05E: supply personnel dedicated to the Division
- 450: personnel responsible for conducting final tests of the F414
- LPO: Leading Petty Officer, responsible for the work center.

Tasks were modeled in terms of duration, required skills, priority, and complexity. Modeled tasks are presented in Figure 3. The following is a general description of the F414 maintenance process.

After the engine is received, AZ personnel begin by comparing information in the engine logbook to information in two central databases which track engine parts and engine movement prior to maintenance action commencing on the engine, AZ personnel must resolve any discrepancies. Once completed, 41V personnel conduct a major engine inspection (MEI) followed by an engine teardown to determine which engine modules need replacing. Replacement modules are pulled from supply by 05E personnel. The engine is reassembled or “built-up” by 41V personnel, and then sent to the test cell where 450 personnel run it through pre-defined profiles assessing

PLACEHOLDER PAGE FOR 10" X 12.5" PULLOUT
NEW2COLORFIG_C.EPS

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operability. The engine is returned to the maintenance hanger where 41V personnel conduct a post-test inspection. At this point, AZ personnel complete paperwork, and Controller personnel certify the engine as ready for issue (RFI) to an operational squadron. Throughout this process, Controllers are directing the maintenance activities.

To ensure positions were continually occupied throughout the F414 maintenance process, as they would be in reality, off-core tasks were added to the model to simulate maintenance work being accomplished by personnel other than maintenance of the single engine being modeled.

Meetings were modeled in terms of duration, who attended, priority, and interval time between meetings. Meetings were a key method of reliably transferring information between personnel. In general, the Division had a set of morning meetings and a set of afternoon meetings.

Rework was modeled as a percentage of work accomplished. Most F414 rework occurred at the test cell phase of maintenance. The percentage of rework was based on 400 Division estimates.

Additional organizational characteristics modeled included the overall experience level of the Division; the degree of centralized control; the degree of formality in transferring information, i.e., meetings versus hallway conversation; and the matrix strength or connectedness of personnel.

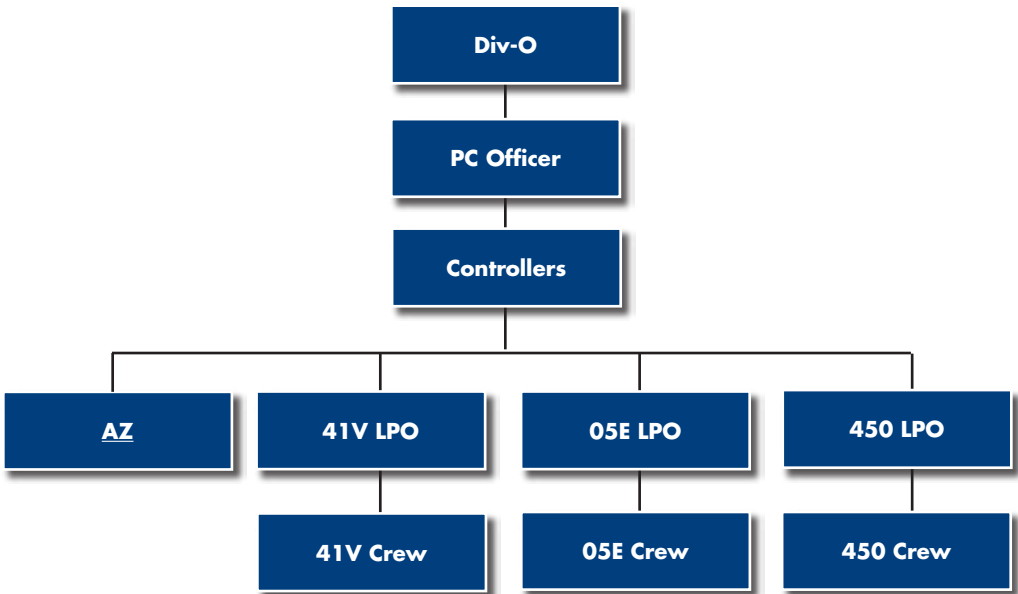


FIGURE 2. NAS LEMOORE AIMD 400 DIVISION
INFORMATION HIERARCHY

MODEL VALIDATION PROCEDURE

Once the model was constructed, the maintenance duration predicted by the model was compared to the actual time it should take to conduct engine maintenance. The actual time was calculated by summing the duration of all tasks occurring in series and the longest duration task of any grouping of tasks occurring in parallel. The smaller the difference was between these values, the higher the confidence in the model, and hence the predicted impacts of interventions.

MODEL INTERVENTIONS

Once the model was determined to accurately depict the current organization, modifications or interventions were made to evaluate alternate organizational constructs, which might reduce throughput duration. The following interventions to the baseline model were evaluated.

- Intervention No. 1—Parallel AZ Acceptance task with other maintenance tasks
- Intervention No. 2—Combine AZ and Controller positions
- Intervention No. 3—Combine 41V and 450 positions
- Intervention No. 4—Decrease organization’s centralization

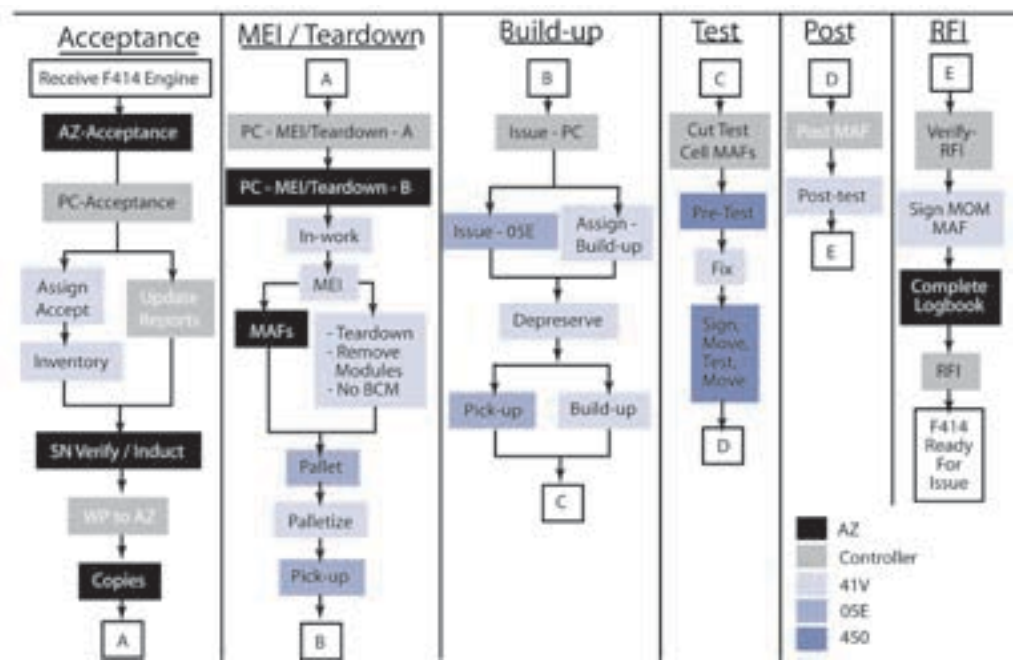


FIGURE 3. WORK BREAKDOWN STRUCTURE OF THE F414 ENGINE MAINTENANCE PROCESS

- Intervention No. 5—Add additional personnel to each position
- Intervention No. 6—Alter current meetings' duration and frequency
- Intervention No. 7—Combine meetings
- Intervention No. 8—Combined intervention

The current F414 maintenance process presented in Figure 3 shows a serial process initiated by the AZ Acceptance tasks.

Intervention No. 1. This intervention is considered the impact of conducting the AZ Acceptance tasks in parallel with all other maintenance tasks.

Intervention No. 2. Personnel assigned to the AZ and Controller positions are combined into a single position. This position is assigned the combination of tasks originally assigned to the separate positions. This intervention was evaluated in two sub-interventions, first without retraining individuals and then with retraining.

Intervention No. 3. This intervention is the same as Intervention No. 2 with the work positions combined.

Intervention No. 4. One of the impacts of *AIRSpeed* is to decrease the centralized control of an organization by pushing authority for decision making to the lowest possible level. This fourth intervention assesses the impact of the Division, further decreasing centralization.

Intervention No. 5. This intervention assessed the impact of adding additional personnel to existing positions. Personnel were added separately to AZ, Controller, 41V Crew, 05E Crew, and 450 Crew positions while holding personnel at all other positions constant.

Intervention No. 6. Considering maintenance tasks are well-defined and the personnel are highly skilled, it's conceivable that altering meeting duration and or frequency may decrease F414 throughput duration. This intervention evaluated altering the duration and frequency of the 0700 morning meeting, their primary coordination meeting.

Intervention No. 7. For the same rationale as Intervention No. 6, this intervention evaluates the impact of first combining all of the morning meetings while leaving the afternoon meetings separate, and then evaluates the impact of separately combining all morning meetings and all afternoon meetings

Intervention No. 8. Based on the results of the single interventions, a combined intervention was developed that included Interventions 1-7, which decreased the F414 maintenance throughput time.

EVALUATING INTERVENTIONS

Interventions were evaluated by comparing four metrics predicted by the baseline model to those predicted by the models with interventions. The first metric was project duration—the duration required to accomplish maintenance of a single F414. Duration was considered the most important metric. The second metric was position backlog—a measure of the number of days of work a position has yet to accomplish. Position backlog is analogous to the size of a person's in-box. A position

with a high backlog poses a risk of increasing project duration and decreasing output quality. Position backlog is presented as a line graph of number of backlog days over time. The third metric was cost. Although absolute cost was not a concern for this study, changes in costs resulting from interventions were. Of particular interest were interventions resulting in increases in costs associated with the major tasks of engine teardown, buildup, and test. Cost was calculated by the simulation based on project duration and output in both text and graphic. The fourth metric was functional risk, the risk that an engine has defects due to rework and the inability of personnel to handle problems. Functional risk increases when an exception occurs and the supervisor does not respond, leaving the employee to decide whether to conduct rework or continue with the task at hand. Qualitative comparisons of functional risk were made using output charts of the functional risk.

For any given intervention, the impact on each of the four metrics was categorized as positive, negative, or no impact and given a rating respectively. For example, a decrease in project duration resulting from an intervention would be considered positive, while an increase in cost or risk would be considered negative

RESULTS

The Results section begins with a presentation of the baseline model validation results. The baseline model is followed by a summary of the results of the seven individual interventions and the combined intervention. Finally, there is a discussion of which interventions were implemented and their impact on F414 maintenance duration.

BASELINE MODEL EVALUATION

The actual time required to conduct F414 maintenance was calculated to be 21.77 workdays as compared to the baseline model prediction of 21.09 days. Since these two durations were within 3% of each other, there was high confidence that the baseline model was accurate.

INTERVENTIONS—SUMMARY OF RESULTS

Table 1 presents a summary of the intervention results. The first intervention, paralleling the AZ Acceptance Task, has the greatest benefit on decreasing F414 throughput duration. Other interventions that were beneficial included decreasing centralization and separately combining the morning and afternoon meetings. The combined intervention, incorporating all of these beneficial interventions, resulted in a 35% decrease in F414 throughput duration while slightly decreasing the backlog of most of the personnel. A detailed discussion of the analysis and results associated with Intervention No. 1 is presented in the following discussion. All other interventions, including the combined intervention, were analyzed in the same manner.

Intervention No. 1, paralleling the acceptance task with maintenance, decreased project duration by 7 workdays from the base model prediction of 21.09 days to

13.77 days (See Table 1). This intervention was considered beneficial because it resulted in a significant decrease in project duration, a slight decrease in position backlog, no significant impact on cost, and only a slight increase in functional risk for a single task.

INTERVENTION NO. 8—COMBINED INTERVENTION

The combined intervention included the following interventions, which were chosen for being the most beneficial:

- Intervention No. 1—Paralleling the Acceptance Task
- Intervention No. 4—Decreasing Centralization from High to Low
- Intervention No. 6—Decreasing 0700 meeting frequency to every 2 days
- Intervention No. 7—Separately combining morning and afternoon meetings

The impact of these combined interventions on project duration was a decrease from 21.09 days to 13.72 days. The backlog for most positions decreased with an increase in only one position, the 450 LPO. There was a slight increase in Teardown task rework cost from \$26.44 to \$36.93 per unit, and a slight decrease in the Buildup task rework cost from \$48.43 to \$22.13 per unit. Overall, the changes in cost were not considered significant. Finally, there was no significant impact on functional risk.

ASSESSMENT OF INTERVENTIONS

The results of this study lead to the conclusion that four of the seven interventions to the Division considered in this study would be beneficial to reducing the throughput duration: paralleling the AZ Acceptance task, decreasing centralization, decreasing 0700 meeting frequency, and separately combining morning and afternoon meetings.

The greatest benefit to reducing the F414 throughput duration comes from paralleling the AZ Acceptance task. Although this intervention increases functional risk, this increase is minor relative to the decrease in throughput time by 7.21 days. There is also a decrease in position backlog.

Decreasing centralization, a benefit realized through the implementation of *AIRSpeed*, also has a positive impact on decreasing F414 throughput. This intervention resulted in a 4.4-hour decrease in duration.

By decreasing the 0700 meeting frequency from every day to every other day, F414 throughput duration decreases by 6.56 hours. This benefit is the result of a highly skilled workforce executing well-defined tasks allowing personnel to spend more time working on engine maintenance and less time exchanging information in meetings.

By separately combining morning and afternoon meetings such that there is one morning meeting that all personnel attend and one afternoon meeting, F414 throughput duration decreases by 7.28 days. At the same time, there is also no increase in functional risk.

Unfortunately, benefits associated with combining these four interventions are not additive. This makes sense based on their interrelated nature. When combining

TABLE 1. SIMULATION RESULTS FOR INTERVENTIONS BY DURATION, BACKLOG, COST AND RISK

Intervention	Project Duration	Backlog	Cost	Risk
1. Parallel AZ Acceptance	58.56 hour decrease	Decrease most positions	No significant impact	Increase in AZ Acceptance task risk
2a. Combine Controller & AZ positions without training	110 hour increase	Decrease controller & AZ, Increase for Div-O & PC	AZ Acceptance task work & rework cost increase by 205.6 & 11.72 respectively	Increase in AZ Acceptance task risk
2b. Combine Controller & AZ positions with training	56.7 hour increase	Decrease in Controller & AZ backlog. Increase for Div-O & PC	AZ Acceptance task work & rework cost increase by 140.1 & 18 respectively	Increase in AZ Acceptance task risk
3a. Combine 41V and 450 positions without training	132.6 hour increase	Slight decrease in 41V and 450 backlog	Increase costs: Buildup & rework – 267.16 & 7.2, Test work, rework, and wait costs – 1085, 61.5, 290.2	3/4 top risk areas assigned to combined 41V-450 vs 2/4 currently
3b. Combine 41V and 450 positions without training	67.6 hour increase	Slight decrease in 41V and 450 backlog	Increase costs: Buildup work – 267.15 & test work, rework, and wait costs – 303.4, 5.63, 93.41	3/4 top risk areas assigned to combined 41V-450 vs 2/4 currently
4. Decrease Centralization	4.4 hour decrease	No significant impact	Slight increase in Buildup task rework costs of 9.86	No significant impact
5a. Add AZ personnel	1.87 min saved / person	No data collected	No data collected	No significant impact
5b. Add Controller personnel	6.82 min lost / person	No data collected	No data collected	No significant impact
5c. Add 41V Crew personnel	0.91 min lost / person	No data collected	No data collected	No significant impact
5d. Add 05E Crew personnel	10.51 min saved / person	No data collected	No data collected	No significant impact
5e. Add 450 Crew personnel	4.42 min saved / person	No data collected	No data collected	No significant impact
6a. Vary 0700 meeting duration & frequency	6.56 hours saved due to less frequent meeting	No data collected	No data collected	No significant impact
6b. Vary 0630 meeting frequency	1.6 hours saved due to less frequent meetings	No data collected	No data collected	Slight increase in risk when increasing time between meetings
7a. Combine only morning meetings	No significant impact	No data collected	No data collected	No significant impact
7b. Combine morning into one meeting and combine end of day meetings into another meeting	7.28 hours saved by decreasing meeting frequency to every other day	No data collected	No data collected	No significant impact
8. Combined Interventions	58.96 hours saved	Decreases most positions. Increases 450 LPO	Buildup rework decreases by 26.3 and Teardown rework increases by 10.49	No significant impact

interventions, the benefit to reducing F414 throughput duration is nonetheless significant in that there is a reduction of over 35 percent from the baseline case representing the current organization. In conjunction with this benefit, there is a decrease in backlog for all positions excluding one, the 450 LPO, and there is no adverse impact to cost or functional risk.

Two other interventions considered, combining the AZ and Controller positions and combining the 41V and 450 positions, resulted in increases in F414 throughput duration, and increases in cost and risk with the only predicted benefit being a decrease in position backlog for the combined positions. Clearly, these interventions are not beneficial.

Finally, the intervention associated with adding additional personnel did not affect F414 throughput duration and had no impact on risk. Obviously, there would be no benefit to implementing this intervention.

RECOMMENDED INTERVENTIONS

The NPS recommended the 400 Division implement the following four interventions:

- Recommendation No. 1—Decrease 0700 morning meeting frequency to every other day.
- Recommendation No. 2—Combine morning meetings
- Recommendation No. 3—Combine end-of-day meetings
- Recommendation No. 4—Parallel AZ Acceptance task

The first recommendation should be implemented followed by a period of evaluation. Each subsequent intervention should be implemented also followed by a period of evaluation. The priority order of these interventions is based on first implementing those interventions that can most easily be reversed. For example, conducting the 0700 meeting every other day is a relatively easy organizational change, which should result in a decrease in F414 throughput duration. At the same time, it is an organizational change that can be reversed if deemed necessary.

IMPACT OF IMPLEMENTING INTERVENTIONS

The NAS Lemoore AIMD and 400 Division leadership had significant confidence in the results of this study, and chose to fully implement Recommendation No. 4 to parallel the AZ acceptance task while partially implementing Recommendation No. 3 to separately combine the morning and afternoon meetings. The impacts of these decisions were quickly realized and deemed successful. The following discussion presents three instances in which paralleling the AZ acceptance task significantly reduced F414 maintenance throughput time. Table 2 at the end of this section presents a summary of these results. Following this is a discussion of how partially combining 400 Division morning meetings improved organizational performance.

On October 20, the 400 Division received F414 serial number 868472 from VFA106, NAS Oceana. On that same day, the engine acceptance process commenced.

During the acceptance process SAME database problems were identified. Recall that the SAME database, described earlier in this article, is a historical record of maintenance actions accomplished on each engine. Often an engine is received by the 400 Division that has discrepancies between data contained in the SAME database and the engine log book. These SAME discrepancies were resolved on November 7. Prior to implementing the intervention of paralleling the AZ acceptance process, teardown would not have started until after the SAME database problems were resolved on November 7. By implementing this intervention, engine maintenance began on October 23 when personnel were available, which saved 16 days—the difference between starting engine maintenance on October 23 versus November 7 (Table 2).

In the second observation, on October 25 the 400 Division received F414 serial number 868083 from VFA-2. SAME database problems were identified on October 26, which were resolved on November 13. By choosing to implement the intervention of paralleling the AZ acceptance process, maintenance on this engine commenced on October 29 versus waiting until November 13, thus saving 16 days—the time from October 29 to November 13.

In the third example, on September 5 the 400 Division received F414 engine serial number 868265 from the *USS Lincoln*. On that same day, SAME database problems were identified that were eventually resolved on October 16. A total of 46 days was saved in this case by paralleling the AZ acceptance process since maintenance on this engine started on September 6 versus waiting until the SAME problems were resolved on October 16 (Table 2).

Like the impacts presented in Table 2, the AIMD and 400 Division leadership’s decision to combine certain aspects of their morning meetings also had a positive impact on decreasing the time required to conduct F414 maintenance. Specifically, LPO coordination efforts conducted at both the 0630 and 0700 meetings were combined. At the same time, the duration spent by each LPO in this combined meeting was decreased, which allowed them to more quickly provide direction to their subordinates.

At the time of this article’s writing, this intervention had just recently been implemented, and quantitative results of its impact were not yet available. Qualitatively, though, the Division Officer (Div-O) in charge of the 400 Division has identified a marked improvement in the amount of work being accomplished

TABLE 2. SUMMARY OF INTERVENTION RESULTS

Engine Serial Number	Engine Received	SAME Problem(s) Identified	SAME Problem(s) Resolved	Engine Maintenance Started	Days Saved
868472 VFA-106	20 Oct	20 Oct	7 Nov	23 Oct	16
868083 VFA-2	25 Oct	26 Oct 06	13 Nov	29 Oct	16
868265 <i>USS Lincoln</i>	5 Sep	5 Sep	16 Oct	6 Sep	46

as a result of implementing this intervention. Prior to its implementation, upon his arrival to the office at 0630 each day, the Div-O would see a significant amount of coordination work being accomplished by LPO and PC personnel in preparation for the day's work. Following the combination of morning meetings, the Div-O arrives at work and now sees personnel working on the F414 engines. Information flow is being

Information flow is being accomplished more smoothly, thus allowing coordination efforts to be accomplished more quickly, and hence more work accomplished in a given day.

accomplished more smoothly, thus allowing coordination efforts to be accomplished more quickly, and hence more work accomplished in a given day.

The AIMD and 400 Division leadership are pleased with the results of these interventions. Both quantitatively and qualitatively, their impacts have resulted in shorter F414 throughput time and improved organizational performance through better information flow.

LIMITATIONS AND FUTURE RESEARCH

This project only considered that portion of the AIMD 400 Division that accomplishes F414 maintenance. It considered only tasks associated with maintenance efforts starting from receipt of the engine to the point at which the engine is determined to be ready for issue (RFI). Although other maintenance work and collateral duties not directly associated with F414 maintenance were not directly modeled, generic, non-core tasks were modeled, which required personnel to perform functions other than F414 maintenance. By doing so, limitations on 400 Division personnel's time to accomplish F414 maintenance were accurately characterized. The scope of this effort was further limited by modeling the maintenance of only a single engine, although total available time to accomplish tasks was correspondingly decreased to that available for a single engine.

Future research is needed to track AIMD performance post-implementation of selected interventions and compare to predicted performance. Other organizations within the NAS Lemoore AIMD, e.g., Airframe Division, Avionics Division, etc., should also be separately modeled to identify potential organizational changes that may improve their processes. Consideration should then be given to integrating these separate models to develop a coherent AIMD model, which would aid in identifying modifications to the larger organization, which would benefit information flow. The model developed for this study could also be modified to represent engine maintenance divisions in other AIMD units across the Navy and DoD.

CONCLUSIONS

This study in applying organizational modeling to the NAS Lemoore AIMD identified several potential modifications or interventions to the 400 Division, which could reduce F414 engine maintenance throughput time. These interventions went beyond the process improvement techniques implemented by the Division under the *AIRSpeed* program by focusing primarily on improving how and when the flow of information through the organization occurs.

Results have shown a savings between 16 and 46 days of maintenance time on each engine, an average of 26 days per engine. The leadership also chose to partially implement the intervention of separately combining morning and afternoon meetings. Personnel now receive direction on required daily maintenance actions more quickly, which has increased the amount of work accomplished each day.

Organizational modeling provided key insights into improving the NAS Lemoore AIMD F414 maintenance process and allowed management to consider the likely impacts of alternatives on time, cost, and quality prior to making these changes. The significant improvement in reducing F414 maintenance throughput time that resulted from this study affords high confidence in achieving future improvements in other Navy maintenance organizations via the tools and techniques of organizational modeling.

Organizational modeling has great potential for improving on outstanding process improvement results the Navy has already achieved under the *AIRSpeed* program.



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ON THE ROAD TOWARD CONFIRMING AUGUSTINE'S PREDICTIONS AND HOW TO REVERSE COURSE

Jan P. Muczyk

Military history teaches us that “wonder weapons” are not an adequate substitute for large numbers of simpler but effective counterparts. On the contrary, it teaches us that quantity has its own quality advantages. However, quantity can only be attained by short product development cycles, and that is only achievable if the Department of Defense relies wherever practicable on an evolutionary approach utilizing low-hanging fruit and off-the-shelf commercial components. This article examines not only an evolutionary approach, but also presents counterexamples relying on transformational technology. The final strategy needs to be a well-reasoned combination of both.

Norman R. Augustine, former CEO of Lockheed Martin, former Under Secretary of the Army, as well as a former executive and manager within the ranks of a number of important defense industries, half-facetiously made the following statement. If present trends continue, he predicted—

In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3-1/2 days each per week except for leap year, when it will be made available to the Marines for the extra day.

CAUSES OF AUGUSTINE'S CONCERNS

The causes of the trends leading to Augustine's tongue-in-cheek hyperbole are manifold, but easily understood. First, flag officers want their weapon systems to do everything. Second, they wish to make changes throughout the development cycle of

the weapon system. To avoid cost escalation resulting from change orders, a “drop dead” date for change orders must be established and rigorously enforced. Third, the federal bureaucracy guarantees inefficiencies. For example, Inspectors General of the DoD routinely conclude that the DoD’s books are un-auditable and that the DoD cannot account for billions of dollars of assets. One estimate actually exceeds a trillion dollars (<http://www.hiddenmysteries.org/news/america/usa/091501g.html>). Fourth, there is a reluctance to purchase extant systems developed by other nations. For example, the Army was reluctant to purchase rocket-propelled grenade (RPG) countermeasures—for example, the Trophy Active Protection System developed by the Israelis—until pressured to do so.

All four reasons escalate the cost of a weapon system, compelling Congress to limit the budget for these expensive systems. As a result, the Defense Department reduces the number of units that it intends to buy to stay within the budget, thereby inflating the cost on a per-unit basis to astronomical proportions. The entire situation is exacerbated by the consolidation of defense contractors and Congressional pressure to buy American, both of which restrict competition. Little wonder then that DoD contract overruns are routine and of epidemic proportions (Rothenflue & Kwolek, 2006).

COLD WAR MENTALITY DIES HARD

Despite the end of the Cold War in 1991, the reason flag officers desire their weapon systems to do everything is because of the persistent Cold War mentality. Even today, the Cold War mentality, with its emphasis on traditional big-ticket items such as combat planes, aircraft carriers, submarines, main battle tanks, and a long, impressive logistics chain, continues to drive defense policies and weapon acquisition strategies. For example, the DoD is spending more money on fighter aircraft (F/A-18E/F, F-22A, and F-35) than at any other time in the nation’s history. The cancellation of the Crusader artillery and the Comanche helicopter, and the development of the Stryker combat vehicle are examples to the contrary. When flag officers are reminded of the end of the Cold War, they bring up China’s potential as a military adversary for which the United States needs to be ready.

STAGGERING COST OF TRANSFORMATIONAL TECHNOLOGY

The B-2 bomber was designed to loiter undetected over Soviet territory in order to locate and destroy mobile multiple independently targetable reentry vehicle (MIRV) missiles. While the B-2 bomber never possessed that capability, it was built nonetheless at a price tag of approximately \$2 billion per aircraft, which resulted in a fleet of 21 planes, and required retaining the B1B and the B-52 fleets. Clearly, maintaining three small bomber fleets of different planes is more expensive than one larger fleet of the same plane. The bomber attrition from one raid over Germany during World War II (WW II) was considerably greater than the entire B-2 fleet. The fact that the B-2 is much more capable than the B-17, B-24, or B-29 is duly noted by the author. The irony, however, is that of the three bomber fleets, given contemporary threats, the B-52 is the most cost-effective to operate, and its standoff weapons probably the most versatile.

Had the U.S. Air Force upgraded the B1B in an evolutionary manner much the same way it modernized the B-52, it would have produced a much larger and less expensive bomber fleet. Both the B-52 and the B1B were initially designed to carry only thermonuclear weapons. To the Air Force's credit, both bombers were later modified to carry conventional weapons as well, thereby making them more utilitarian in conventional conflicts. Hopefully, when the Air Force needs a better bomber than the B-2, it will improve the B-2 with an evolutionary strategy rather than designing a new bomber with expensive and untested transformational technology.

The F-22A is another excellent example of Cold War mentality and buttresses Augustine's point. It was intended to neutralize the fifth generation Soviet air superiority fighter, which will never see the light of day because of the disintegration of the Soviet Union and the resulting inability of Russia to fund it. Pentagon folklore

***Increasing cost estimates, in all likelihood, will compel
Congress to limit its budgets . . .***

has it that the 22 stands for the number of years that it took to develop the plane. The Raptor's budget is \$65 billion, and that will buy 183 planes. That equates to \$355 million per aircraft. Yes, it can go supersonic without afterburners, but that requires two very powerful engines to take supersonic something as large and heavy as the F-22A. Consequently, those engines consume vast quantities of fuel, thereby negating much of the savings resulting from avoidance of afterburners. Its 360-degree low observable characteristics are indisputable, but they come at a staggering price.

During the Cold War, wargaming indicated that the Warsaw Pact numerical superiority would destroy NATO's air capability in about one month. Since NATO was unwilling to match the Warsaw Pact plane for plane, the U.S. Air Force bought into the Rand Corporation recommendation of low observable technology—hence the F-22A as a solution. Again we have the “technology complex” raising its expensive head.

The F-35 Joint Strike Fighter, another example of the “technology complex,” was projected to be cost-effective compared to the F-22A; but, with regard to cost, the F-35 is on the same glide path as the F-22A, notwithstanding the fact that 360-degree low observable capability was sacrificed in order to keep the cost down. Increasing cost estimates, in all likelihood, will compel Congress to limit its budgets, thereby forcing the DoD to reduce the number that it intends to purchase. All that will dramatically increase unit costs, leading to an inevitable sense of déjà vu among the DoD's budget planners.

Moreover, will the latest technological developments prevent the same problems that confronted the tactical fighter experimental (TFX) when an attempt was made to serve everyone's needs with variants of one basic airplane? Furthermore, the possibility always exists that the enemy or potential enemy will develop technology

that will negate the advantage currently enjoyed by low observables. In addition, many weapon systems rely on satellite-based sensors, and these satellites revolve the earth completely naked. Perhaps the greatest danger associated with lengthy product development cycles is the mission obsolescence of the weapon system before it's even fielded because the facts on the ground change so fast. While a number of expensive high-tech weapons are suspect, only the Comanche helicopter has been axed for that reason.

The most thought-provoking question, however, is: Compared to the A-10 Thunderbolt II, how useful are these weapon systems when it comes to killing terrorists and fighting counterinsurgencies—today's dominant contemporary and near-term threats? Undeniably, the Department needs to increase the end strength of the Army and Marine Corps, equip warfighters with proper equipment to wage counterinsurgency wars, and train them to do the same—an expensive proposition indeed. Yet, these very expensive weapon systems must compete for the budget to do just that.

Other examples of Augustine's concerns are the V-22 Osprey, the Strategic Defense Initiative, otherwise known as Ballistic Missile Defense (BMD), and the Airborne Laser System. All three systems are taking a long time to develop, experiencing numerous failures, and having their value questioned by critics. For example, the Ballistic Missile Defense was initiated in 1983, and as of mid-2006 has cost the taxpayer over \$100 billion, with each test costing between \$80-\$100 million (*Dayton Daily News*, 2006). Insofar as the Space Based Infrared System is concerned, the unit cost has escalated from \$4.1 billion to \$10.2 billion (315%). The Air Force could have procured many more Boeing 747 freighters for the amount that it paid for its C-17 fleet. Again, the question arises: just how much value do the additional capabilities of the C-17 provide in today's combat environment? While the V-22 Osprey (\$54.6 billion budget or \$80 million per aircraft) is being sent to Iraq to be "battle tested," the operational restrictions imposed on it are so limiting that they could prevent the V-22 from fulfilling the longstanding mission and performance the Marines will need and expect of the Osprey (Wayne, 2007).

THE LAW OF UNINTENDED CONSEQUENCES

A number of the Cold War weapon systems, such as the B-2, F-22A, and the Ballistic Missile Defense (BMD), were built as much to demonstrate the superiority of free-market democracies over totalitarian command economies as for their military advantage. However, in an attempt to keep up, the Soviet economy crashed, bringing down the Soviet empire without a shot being fired. From that perspective, these exorbitantly expensive weapon systems did their job quite well.

THE SIMPLISTIC TESTING CAVEAT

When it comes to high-tech weaponry, the DoD has a habit of manufacturing simplistic testing to lock in the weapon system, anticipating that technological advancements will eventually make the weapon system viable. A string of examples

can be pinpointed starting with the Bradley Fighting Vehicle. So far, the BMD tests have been equally unrealistic as well. The V-22 Osprey's performance is compared to the performance of outdated helicopters in order to make it look like the "smart" buy. The combat exercises between F-15s flown by U.S. Air Force pilots and MiG and Sukhoi aircraft flown by Indian Air Force Pilots were rigged to show the F-15 as demonstrating significant vulnerability, thereby further justifying the F-22A, which has been under continuous scrutiny for possible termination because of its exorbitant cost and nagging problems associated with its development (<http://kuku.sawf.org/articles//139.aspx>).

Another example of a deceptive test is simulated combat by the F-22A against existing F-15s. A much more meaningful test would be against F-15s upgraded with more powerful engines with thrust vectoring capability, more powerful radar, integrated avionics, air intakes that conceal turbofan blades from radar (of the trapezoidal variety found on the F-18E/F), and coated with the same radar absorbing material as used on the F-22A. Sometimes the "simplistic testing approach" works and sometimes it doesn't. In either case, such a simplistic approach is an expensive way to do business.

Sometimes the "simplistic testing approach" works and sometimes it doesn't.

We must remind ourselves that Pentagon secrecy serves two purposes. At times, it keeps important information out of the hands of enemies and potential enemies. In other instances, it serves as an effective cover for incompetence.

Also, one can only wonder how much better the F-35 Joint Strike Fighter would perform if it had to compete against F-16s upgraded with a more powerful engine with thrust vectoring, a more powerful radar, integrated avionics, air intakes that hide the turbofan blades from radar (of the trapezoidal variety found on the F-18E/F), and covered with radar absorbing coating, as opposed to competing with extant F-16s.

SPURIOUS ARGUMENTS TO JUSTIFY NEXT GENERATION OF HIGH-TECH WEAPONS

The DoD points to countries that now possess aircraft that can challenge the F-15 and the F-16 in order to justify high-tech fifth generation aircraft. The reality, however, is revealing: If one were to place pins on a map of those countries DoD cites in justifying high-tech fifth generation aircraft, it becomes readily apparent that most of them are flying F-15s, F-16s, and F-18s *that the United States sold to them*. The Eurofighter and the Rafael are also used as examples, but they are produced by

our allies. Keep in mind that friendly nations (India as an example) fly MiGs and Sukhoi aircraft, as do NATO allies (Poland for example). And Russia itself, while a competitor, is no longer viewed as a strategic enemy.

WORLD WAR II LESSONS UNLEARNED

Since the beginning of the Cold War, the DoD has counted on a smaller number of weapons built with transformational technology to neutralize the numeric superiority of the weapons inventory possessed by the Warsaw Pact. Yet, the WW II experience does not justify the childlike faith in technology with which some of our defense planners are imbued. Soviet military planners understood clearly the perspicuous lessons learned on the battlefield: *that quantity has its own quality advantage*, both in military as well as economic terms.

We should not be reluctant to take seriously Russian military lessons from a nation that defeated the Tartars, Charles XII of Sweden, Frederick the Great of Prussia, Napoleon Bonaparte, as well as the German army and air force during WW II. Indisputably, this is certainly an impressive array of vanquished adversaries.

We should not be reluctant to take seriously Russian military lessons.

Tank warfare during WW II constitutes a good example. While the Soviet T-34 was the best tank during that war until the German Tiger and King Tiger tanks came on the scene, the Soviets still needed prodigious numbers of that tank to defeat German armor. The U.S. Sherman tank was inferior in most respects to the German counterparts, but we prevailed with it because we possessed it in massive numbers.

Air warfare supports the tank warfare example. The German Me-262 jet fighter, even with its considerable speed advantage, had little bearing on the air war because of its limited numbers. The United States, however, prevailed in the air in Europe and in the Pacific because it possessed massive bomber and fighter fleets. Of course, this includes the many aircraft carriers with their air wings. A fact not widely appreciated in the West is that the largest air battles took place on the eastern front, and the Soviets prevailed because they possessed effective aircraft in vast quantities.

In like manner, the German advantage in rocket technology did little to influence the outcome of the war. The much simpler Soviet Katyusha rocket had a much greater impact, in part due to its ubiquitous presence on the battlefield. The Germans feared the Katyusha rockets to the point that captured Soviet prisoners who operated the Katyushas were executed on the spot. A recent interesting parallel is Hezbollah, which relied heavily on the shock effect of Katyusha rockets in the latest conflict with the Israelis.

Another little-known fact is that the Japanese, with the assistance of their German ally, also spent a fortune on “wonder” weapons during WW II to no avail. Expending that money on conventional weapons would have made the Japanese and the Germans more potent adversaries. However, transformational technologies such as thermonuclear weapons, intercontinental ballistic missiles, low observables, computers (hardware and software), and precision guided munitions serve as excellent counterexamples.

WRONG LESSONS LEARNED TOO WELL

Both Persian Gulf wars and the temporary defeat of the Taliban provide U.S. military planners with rather trivial lessons. High-tech weapons can defeat third-rate armies rather quickly in a conventional force-on-force encounter. Those who trumpet the Iraqi military and the Taliban forces as worthwhile adversaries should remind themselves “little” Israel defeated much of the Arab world over and over again, and in short order. World War II, the Korean conflict, the Vietnam War, and the Iraqi and the Taliban insurgencies offer much more important lessons.

BUILDING WEAPON SYSTEMS FROM LOW-HANGING FRUIT

CRITICAL NATURE OF SHORT CYCLE TIMES

Even without the threats posed by the Soviet Union, the world remains not only dangerous, but seemingly even more so. Future threats will be far less predictable than those during the Cold War era. Consequently, future DoD leaders will have to name that tune after hearing just a few notes, and short cycle times will give them the ability to fashion appropriate and affordable technological responses. Since our enemies and potential enemies will have access to much the same technology as we possess, we must acquire dominance of product development cycle time in order to maintain our competitive edge on future battlefields.

Furthermore, time is money, and in a resource-constrained environment, reducing cost by reducing cycle time is critical. On the one hand, relying on transformational technology is tantamount to a long, expensive product development cycle. On the other hand, developing weapons systems from low-hanging fruit pretty much guarantees short, less expensive product development cycles.

Of course, shorter product development cycle times are every bit as important in the commercial as in the military sectors (Muczyk, 1997). Relying on off-the-shelf commercial components rather than on military specifications is vital when it comes to reducing product development cycle time and cost. A case in point is the Gyrocam Triple Camera system, which mounts on armored vehicles, helps ferret out roadside bombs, allows troops to see over berms to watch for ambushes, and has proven invaluable during darkness. The system was first developed for TV news helicopters (Bayles, 2007). Undeniably, in the field of electronics, on which practically all

military systems depend, technology is developed for commercial applications. Clearly, the product development cycle is not the only element of efficiency and/or effectiveness. For more complete expositions, see Muczyk (1997, 1998).

THE MOST VITAL PHASE OF ANY WEAPON SYSTEM

The “make or break” phase of any weapon system insofar as completing it on time, on cost, and within performance specifications is the planning phase because it is through this phase that the technical and economic viability of the weapon system is established, and a prudent timeline assured. For these reasons, this phase must be managed with the greatest care. During this phase, there must be intense oversight not only by the highest levels of the DoD, but also by the appropriate committees and sub-committees of Congress. The individuals engaged in the oversight must ensure that whenever possible low-hanging technological fruit and off-the-shelf components are incorporated into the weapon system, and firms with a proven track record are awarded the contracts. Once oversight and contract award are managed properly, supervision could be minimized so long as the final product is properly tested, and payments are made contingent on meeting specifications. If this is left undone, the weapon system is likely to share the same fate as the F-22A and the other weapon systems that experienced unconscionable overruns with respect to time and cost and serious performance deficiencies.

EXAMPLES OF WEAPON SYSTEMS DEVELOPED FROM LOW-HANGING FRUIT—THE EVOLUTIONARY APPROACH

WORLD WAR II

The Grumman F6F Hellcat fighter shared a heritage with the ineffective F4F Wildcat. But evolutionary improvements, principally the Pratt & Whitney R-2800 Double Wasp engine, made it the best U.S. Navy fighter plane during WW II. It was credited with destroying 5,163 enemy aircraft (http://en.wikipedia.org/wiki/F6F_Hellcat).

The P-51 Mustang was an ordinary plane until it was upgraded with the Packard-built Rolls-Royce Merlin engine and the “bubble” canopy, at which time it became the premier fighter of WW II (http://en.wikipedia.org/wiki/P-51_Mustang).

COLD WAR

U.S. Air Force. The F-117 Nighthawk was constructed with off-the-shelf parts with the exception of the foil and coating. As a result, its product development cycle and cost were uncommonly short and reasonable (schedule slippage of 13 months and cost overrun of merely 3 percent). The RQ-1A Predator is another example of the wisdom of matching maturing technologies with warfighter needs. The U.S. Air Force began taking deliveries of an upgraded RQ-1B less than 5 years from program inception (Rothenflue & Kwolek, 2006).

The GBU-28 Bunker Buster was developed from off-the-shelf parts, tested, and

deployed in 28 days during Operation Desert Storm and proved extremely useful (Muczyk, 1997). Joint Direct Attack Munitions (JDAM) also provide impressive results for a modest investment. Upgrading B-52s with better engines, better avionics, and more capable weapon systems is perhaps the most telling case in point. The modernized KC-135 tanker ranks a close second to the B-52 as a success story of the evolutionary strategy.

In 1999, the F-18E/F program team was awarded the prestigious Collier Trophy, and in 2005 the same team won the Aviation Week Program Excellence Award.

U.S. Navy. The F-18E/F Super Hornet is the evolutionary progeny of earlier F-18 models. As the result of this approach, the U.S. Navy was able to field what it considers to be the most advanced multi-role strike fighter available today and for the foreseeable future. This was accomplished on budget, on time, and on weight. Variants of this plane will replace most of the airframes found on the deck of an aircraft carrier, thereby minimizing production, maintenance, and training costs. In 1999, the F-18E/F program team was awarded the prestigious Collier Trophy, and in 2005, the same team won the *Aviation Week* Program Excellence Award.

The U.S. Navy opted for this evolutionary approach after its transformational A-12 Avenger II was canceled because it proved to be a disaster in every way, but not until a king's ransom was spent on its development. Its cancellation, incidentally, was also quite expensive (<http://www.aerospaceweb.org/aircraft/fighter/f18ef/>).

The Trident II D-5 is the sixth generation member of the U.S. Navy's Fleet Ballistic Missile (FBM) program, which began with the Polaris (A1) in 1956. Clearly, the added capabilities of the Trident II D-5—and they are substantial—were provided in an incremental or evolutionary manner (<http://www.fas.org/nuke/guide/usa/slbm/d-5.htm>).

An excellent example of converting a strategic weapon designed for a World War III thermonuclear exchange into a tactical weapon designed for a localized conventional conflict is the Navy program to convert four Trident ballistic missile submarines (SSBNs) into cruise missile-carrying and special operations forces (SOF) support submarines (SSGNs). While still an expensive proposition with escalating cost, conversion is still cheaper than building such littoral warfighting assets from scratch (http://www.history.navy.mil/library/online/trident_conversion.htm).

U.S. Army. The Patriot Advanced Capability (PAC)-3 terminal phase missile interceptor started out as a surface-to-air aircraft interceptor before the first Gulf War. However, a pressing need quickly prompted its conversion to an anti-missile system whose effectiveness has been increased continuously through the evolutionary process.

Russia. With the collapse of the Soviet Union, Russia was left with no alternative but to upgrade its existing fighter planes. The process began with the addition of thrust vectoring in the Sukhoi (SU)-27 model, which became the SU-37 (Johnson, 1997). Similar evolutionary improvements have been made to the very maneuverable MiG-29.

Clearly, had Russia possessed the financial resources, it would have developed a fifth generation fighter intended to counter the F-22A. One can only speculate how much better it would have been compared to the SU-37 and/or the improved MiG-29. Most certainly, it would have been much more expensive. It appears that a constrained budgetary environment is the mother of the evolutionary approach.

NEW MISSIONS FOR EXISTING TECHNOLOGY

Clearly, there can be no substitute for creativity. When the P-51 replaced the P-47 as the premier air-to-air fighter in the European theater, the P-47, rather than being retired, was converted to the close ground support mission with brilliant success. While the U.S. Army has used “fixed fire bases” in the past to good advantage, the U.S. Air Force, however, has invented the “mobile fire base” by marrying Army fire power with its C-130 aircraft to create the AC-130 H/U. This mobile fire base has provided a great deal of value-added on the battlefield at a very modest cost since the Vietnam War (<http://www.af.mil/factsheet.asp?fsID=71>). Similar creative solutions are desperately needed if we are to arrest the rapid increases in the cost of weapon systems.

KNOWING WHAT PRODUCES THE GREATEST RATE OF RETURN

Most of us recognize that exceptional leadership and capable warriors are still the most important elements of warfare. However, insofar as hardware is concerned, we need to develop an appreciation for those improvements that show promise of providing the biggest bang for the buck. It isn't the improvements in the airframe or the engines of the B-52H that make it such a versatile and effective bomber. Neither is it the advanced avionics. It is the improved suite of weapons—precision guided munitions and air launched cruise missiles (ALCMs)—that the B-52H carries. The same argument can be made for fighter planes. A comparison of the effectiveness of Vietnam-era air-to-air missiles with the effectiveness of today's air-to-air missiles highlights the advantages of today's improved suite of precision weapons. Ditto for the air-to-ground munitions. Navy cruise missiles have immeasurably enhanced the U.S. Navy's surface ships as well as submarines. Much the same can be said for ship-to-ship and ship-to-air missiles.

GROWING THE TECHNOLOGY FRUIT TREE

For there to be a technology tree with important and useful low-hanging fruit, the DoD and the branches of the military must adequately fund basic as well as applied research. The Defense Advanced Research Projects Agency (DARPA), the Air Force Research Laboratory (AFRL), especially through its Air Force Office of Scientific Research Directorate (AFOSR), Air Force Institute of Technology (Graduate School of Engineering and Management), and the counterparts of the Navy, Army, and

Marine Corps should be funded in accordance with the high priority given pressing warfighter needs. Toward that end, DoD must resist the temptation to shortchange basic and applied research so vital to our nation's warfighting technology solutions.

Technological fruit must be grafted onto the tree by the private sector and research universities as well. Incentives should be provided to the private sector so that it would invest some of its own capital to grow the technological fruit tree. For example, a company contributing to the technological fruit tree should have assurances that it will recoup its investment through award of government contracts associated with its contribution to the development of a weapon system.

Lastly, the DoD, in conjunction with its military branches, must scan the international environment for technological fruit to be grafted onto the tree. Collaborating with allies in promising joint ventures is also a viable strategy. The Harrier Jump Jet used by the U.S. Marine Corps and the British Navy is instructive. The original version was developed by the British and the advanced AV-8B version by the Americans. Finally, as technologies mature, they should be incorporated into weapon systems.

LINING UP EXAMPLES WITH CONCLUSIONS

WHEN TRANSFORMATIONAL TECHNOLOGY IS CALLED FOR

When there is an ideological conflict on a world stage between two or three technological superpowers, even though the contest does not erupt into global armed conflict, the superpowers cannot take a chance on being bested by their adversary (ies) because so much is at stake. Therefore, they believe they must pursue transformational breakthroughs as well as evolutionary improvements in existing weaponry. World War II and the Cold War are excellent examples. During the former, the contest was between fascism and democracy (the Soviet Union being an exception), and during the latter the conflict was between democracies and communism.

When a nation's survival is at stake, even without a global ideological struggle as is the case with Israel, transformational technology will be employed as the last resort. The examples presented here are patently obvious: nuclear weapons; intercontinental ballistic missiles; cruise missiles; stealth technologies, especially in aircraft; submarines capable of launching strategic missiles; ballistic missile defense; space-based assets; and biological and chemical weapons as well.

Possession of these transformational weapons by all of the global adversaries predictably leads to a great reluctance to use them because of their destructive power—hence mutually assured destruction or MAD. The prospect of mutual destruction constitutes a major reason why the world has seen regional conventional conflicts during the Cold War but not a global conflagration.

ACQUISITION STRATEGIES FOR REGIONAL CONVENTIONAL CONFLICTS

Korea, Vietnam, both Iraq wars, and Afghanistan have demonstrated the limited value of transformational technology. These conflicts are about adapting existing

weapons to an appropriate strategy in an evolutionary manner if for no other reason than counterinsurgency wars are quite long, and cost is a vital consideration. Unlike WW II and the Cold War, where a large, modern Air Force and Navy were crucial, the regional conventional engagements against terrorists are an Army and a Marine Corps operation that requires large numbers of boots on the ground. Effective body armor; vehicles that can withstand improvised explosive devices and shaped charges; effective intelligence, which requires cooperation from locals; and real-time communications are vital—as is knowing and honoring local customs. While conversion of transformational weapons to fight the Global War On Terrorism (GWOT) is possible—as the B-1B, B-2, and SSGNs so clearly demonstrate—its prohibitive expense cannot be borne indefinitely by this nation as a way to fight the GWOT, which in all likelihood will be intergenerational. The A-10 Thunderbolt II, AC-130 H/U, the RQ-1B Predator, and the Gyrocam Triple Camera systems are much more cost-effective.

While the military may not like fighting counterinsurgency conflicts as a result of the Vietnam experience, it still must be prepared to do so since its civilian leadership may continue to involve the United States in these types of conflicts in the future.

CONCLUSION

The belief by our civilian and military leaders that technology will negate numerical superiority has led to a reliance on transformational technology which, in turn, has resulted in staggering product development costs and unprecedented product development life cycles. This approach perforce mandated small quantities of weapon systems at outlandish unit costs. Unless this situation is reversed, the military will bankrupt itself with little in return, since these systems lend little to asymmetric warfare such as fighting terrorists and waging counterinsurgency conflicts—today's contemporary and near-term threats. According to some estimates, the U.S. defense budget exceeds the defense budgets of all of our allies combined and some of our adversaries. Critics maintain that such a situation cannot be sustained indefinitely, especially if a serious attempt is made to balance the federal budget.

Short product development cycles are the key to large numbers of affordable weapon systems. Toward that end, recommendations have been proffered to redress the problem of long product development cycles by relying on the development of weapon systems from low-hanging fruit and off-the-shelf commercial components instead of military specifications.

Learning from historical and contemporary lessons that quantity has its own quality advantages, both military and economic, in recent years the DoD has made a case for the implementation of acquisition policies calling for the development of more weapons using an evolutionary approach rather than through transformational technology.

For this evolutionary approach to be viable, the United States must continuously grow a robust technological fruit tree by adequately funding the research and development community, and relying on technology developed by our allies through

joint ventures and other mutual defense-industry partnerships.

Examples were also identified whereby transformational technology created a sea change in military affairs. An attribution to Gen. Dwight Eisenhower (probably apocryphal) theorized that the following four assets played the greatest role in winning WW II: C-47, bazooka, Jeep, and the atomic bomb (<http://en.wikipedia.org/wiki/Bazooka>).

Whoever made this observation had a deep insight into large-scale warfare. Consequently, the end result must be a well-reasoned balance between evolutionary and transformational technologies.



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GOVERNMENT CONTRACT BUNDLING: MYTH AND MISTAKEN IDENTITY

Timothy T. Nerenz

The procurement practice of contract bundling is universally regarded as a major barrier to small business participation in federal government contracting. The U.S. Small Business Administration has estimated that 34,221 new bundled contracts were awarded from 1992–2001, transferring \$840 billion of contract revenue from small to large businesses, and causing a 56 percent decline in the number of small businesses contracting with the government. This article summarizes the author's 2006 doctoral dissertation, which tested the validity of those government estimates through analysis of contractor bid protests filed from 1992–2004 with the U.S. Government Accountability Office. The dissertation found that only 25 bid protests were filed by contractors over contract bundling, sharply contradicting the government's estimates of bundling frequency. The dissertation identified the methodological flaw in the government's seminal study on contract bundling that caused overstatement of bundling frequency. The research suggests that contract bundling is in fact a rare and insignificant activity in the government contracting marketplace.

This article summarizes the author's 2006 doctoral dissertation entitled *Federal Procurement Policy Analysis: Has Extent and Effect of Government Contract Bundling on Small Business Been Overstated?* (Nerenz, 2006). The dissertation tested the widely held belief that contract bundling—the combining of separate smaller contracts into a single large contract unsuitable for small businesses—is the most important barrier to small business participation in the \$300 billion-plus federal government contracting marketplace.

The U.S. Small Business Administration has estimated that federal government procurement officials issued 34,221 new bundled contracts from 1992–2001, transferring \$840 billion of revenue from small to large firms, and causing a 56

percent reduction in the number of small businesses participating in government contracting (Eagle Eye Publishers, 2000, 2002).

In its seminal 2002 report on contract bundling, the SBA Office of Advocacy stated, “Bundling is rooted in the Defense sector, where 10 percent of the contracts and 55 percent of the \$1.2 trillion spent on defense contracts were bundled between FY 1992 and FY 2001” (Eagle Eye Publishers, 2002).

The Nerenz (2006) dissertation theorized that these government estimates of contract bundling frequency were materially overstated. It sought to verify the SBA’s statistical studies by examining bid protests filed by contractors over the practice of contract bundling. It can be reasonably expected that each act of improper bundling would be recognized and appealed by the contractors affected; and therefore, the dissertation proposed that counting the number of annual bid protests filed over the practice of bundling would provide a reliable means for testing the validity of the SBA statistical estimates of annual bundling frequency.

Is contract bundling rampant or rare? The answer has two important communities of constituent interest. To the small business strategist, an accurate threat assessment is essential to successful strategy development. To the government acquisition community, the SBA’s high estimates of bundling frequency imply widespread impropriety and non-compliance with procurement policy; conversely, a low volume of bid protests would provide a measure of exoneration for acquisition officials and administrators.

BACKGROUND

The term *contract bundling* is a specific procurement practice—defined by statute as the act of combining two or more requirements previously purchased under separate small business contracts into one consolidated contract that is unsuitable for small business due to size, geographic disbursement, or specialized capabilities and capacity (*Federal Register* §13 C.F.R. Pt. 125). The impact of each bundling action is plainly detrimental to the two or more small businesses that are denied the revenue and profit transferred to a large business when contracts are bundled. As a matter of public policy, the widespread use of contract bundling by government buying agencies is seen to stifle entrepreneurship and discourage small business development (Styles, 2003).

While each act of contract bundling has a localized effect on individual small businesses, it is the *frequency* of the practice that elevated it to an urgent business and public policy concern during the late 1990s. Senator Olympia Snowe, then chairwoman of the U.S. Senate Committee on Small Business and Entrepreneurship, supported the SBA position in a 2003 Committee hearing in which she agreed that contract bundling “has forced more than 50% of small businesses out of the federal contracting marketplace” (Snowe, 2003). Angela Styles, Administrator of the Office of Management and Budget Office of Federal Procurement Policy, stated that by 2001 the practice had “reached record levels” (Executive Office of the President, 2002). Congresswoman Nadia Velazquez described bundling as “rampant” (Velazquez, 2003). Both candidates for President in the 2004 election proposed tough anti-

bundling legislation as a means to support small business development (Kerry, 2001) (Executive Office of the President, 2002).

Describing the deterrent effects of contract bundling on entrepreneurship, the Office of Management and Budget stated “the negative effects of contract bundling over the past 10 years cannot be underestimated” (Styles, 2003). Trade associations and small business advocates have universally condemned the practice, citing statistics published by the Small Business Administration (Eagle Eye Publishers, 2002) in their position papers.

For a subject of such high visibility and importance to policy makers and business leaders, relatively little academic research has been published.

While the issue of contract bundling generated considerable policy debate and advocacy rhetoric during the 1990s, quantitative studies to estimate bundling frequency and impact were not completed until 2000 (Eagle Eye Publishers, 2000). Explicit reporting of the practice by government buying agencies was not implemented fully until 2002 (U.S. Government Accountability Office, 2004). Fewer than 20 objective research-quality documents were located on the subject during literature review of this dissertation, while over 3,400 other documents—trade press articles, press releases, position papers, editorials, and the like—were retrieved in a Web search using the keyword string “contract bundling.” For a subject of such high visibility and importance to policy makers and business leaders, relatively little academic research has been published.

The official federal government positions on contract bundling derive from the statistics reported in a series of three studies of contract bundling published by the U.S. Small Business Administration Office of Advocacy (SBAOA) and performed under contract by Eagle Eye Publishers of Fairfax, Virginia. The first study, entitled *Bundled Contract Study FY 1992–1995* (Eagle Eye Publishers, 1997), estimated the number of bundled contracting actions from fiscal years 1992–1995 by means of a quantitative analysis of individual contract records in the Federal Procurement Data System (FPDS) database. This study identified presumptively bundled contracts by changes in contract size over time and concluded bundling is “increasing and causing harm to small businesses” (Eagle Eye Publishers, 1997).

The second SBAOA study was entitled *Impact of Contract Bundling on Small Businesses FY 1992–1999* (Eagle Eye Publishers, 2000). This study expanded its selection criteria from simple contract size to a more complex scheme of detecting changes in certain field values in FPDS database records—contract type, place of performance, and product/service codes purchased. This study was updated in 2002 (Eagle Eye Publishers, 2002) to extend its findings to a full decade: 1992–2001.

The 2002 edition's findings and conclusions have become the conventional wisdom on the subject, and its alarming statistics are cited universally in articles and policy statements on the issue of bundling and its effect on small business development.

In contrast to the well-publicized Eagle Eye Publisher studies published by the Small Business Administration, other government reports that contradict the Eagle Eye Publishers (2000, 2002) findings were largely ignored. While the U.S. Small Business Administration estimated new bundled contracts occurred at an average of over 3,400 times per year (Eagle Eye Publishers, 2002), the U.S. General Services Administration reported only 928 new bundled contracts were issued in 2002, the first year that contracts were explicitly labeled as "bundled" in the GSA contract records database (U.S. Government Accountability Office, 2004). In its audit of the GSA results, the U.S. Government Accountability Office (2004) found that only 24 of those 928 contracts were actually bundled, while the other 904 were coded or recorded in error.

PURPOSE AND RATIONALE FOR THE STUDY

Business strategies can not be effectively developed without reasonably accurate assessments of strategic threats. Since contract bundling is widely regarded as the most significant threat to small business participation in federal government contracting, accurately assessing whether the annual frequency of the practice is properly measured in thousands, hundreds, or tens of occurrences is important to small business strategists.

In its audit report of the GSA system for recording bundling actions, the U.S. Government Accountability Office (2004) criticized the poor quality of the data in the Federal Procurement Data System (FPDS). FPDS data are the source for both Eagle Eye Publishers (2000, 2002) studies and the U.S. General Services Administration (2002) report. Since the underlying data are a causative factor in generating unreliable results of quantitative analyses, the Nerenz dissertation (2006) sought a new source of information to gain its understanding of contract bundling frequency and effect.

The dissertation developed its understanding of contract bundling frequency and effect through examination of bid protests filed with the U.S. Government Accountability Office (GAO) by small businesses victimized by the practice. The GAO bid protest process is the venue for appeals of unfair and improper government procurement actions (Drabkin & Thai, 2003). Offerors would certainly know if a government contracting officer had bundled a requirement that deprived them of continuation of a contract, and would be aware of their right to appeal the action if the contracting officer acted improperly in bundling the requirements.

The dissertation literature review discovered an SBA official's Congressional testimony (Hayes, 1999) that only six bundling actions had been approved in FY 1998 by his agency through the procedure mandated by statute (*Federal Register* §13 C.F.R. Pt. 125) to properly authorize proposed bundling actions. Since the number of new bundled contracts estimated in the Eagle Eye Publishers (2002) study for FY 1998 was 3,287, all but six of these would have been *improper*, and grounds for a successful bid protest appeal by the affected contractors.

If in fact there were 3,281 improper bundling actions in FY1998, it could be reasonably expected that a comparable number of bid protests would have been filed by the small businesses disenfranchised by those actions. Counting bid protests filed over the practice of contract bundling, therefore, was determined to be a reasonable means for independent validation of the government's statistical estimates of bundling frequency (Eagle Eye Publishers, 2002).

METHODOLOGY

The research design for the dissertation combined qualitative and quantitative techniques to address the specific research questions developed for this study:

1. How many contractor bid protests were filed over the practice of bundling each year from 1992–2004?
2. How does the number of contract bundling bid protests compare to government estimates of contract bundling frequency as published in the 2002 Eagle Eye Publishers report entitled *Impact of Contract Bundling on Small Business 1992–2001*?
3. How does the number of contract bundling bid protests compare to the characterization of contract bundling as the most important problem facing small business in government contracting?
4. How does the number of contract bundling bid protests compare to the estimate that 56 percent of small businesses were driven out of the government contracting marketplace due to contract bundling?

QUANTIFYING BID PROTESTS

To determine the number of contractor bid protests filed over the practice of bundling, the study searched the legal products digital archives of the U.S. Government Accountability Office (GAO) for protest decisions where contract bundling was a primary or secondary ground in the pleading. Documents containing the keywords *bundling* and *protest* anywhere in the full text were retrieved for fiscal years 1992 through 2004 using the search facility provided for public access (<http://searching.gao.gov/query.html>). Confirmation of the record retrieval protocol was sought and received from the GAO webmaster for legal products archives (personal correspondence with D. Harper, July 25, 2005). The keyword search was performed four times on different days, returning the same results each time.

Documents retrieved were then individually screened to eliminate duplicates—documents stored in multiple digital file formats. The remaining population of unique cases was read to expunge cases retrieved in the keyword search but not relevant, either because the term “bundling” was used in a different context (packaging, for example) or because contract bundling was one of several tangential complaints listed in cases where pleadings and decisions focused on other disputes unrelated to bundling. The remaining population of unique and legitimate bundling protest cases was logged into an Excel electronic spreadsheet for future sorting and analysis.

A second segment of the study examined 14 other grounds for contractor bid protests to test the validity of the claim that bundling was the biggest problem facing small businesses. Using the same search protocol described for bundling cases, each of the other 14 grounds was entered into the keyword search string, and the number of document “hits” returned from the archives database was recorded. This procedure was repeated twice to insure validity. The results of the searches (numbers of document hits) were recorded in an Excel electronic spreadsheet and the 15 grounds (including the contract bundling initial return counts) sort-ranked.

COMPARING DATA SETS

To test the research hypothesis that the number of bid protests found would invalidate the Eagle Eye Publishers (2002) estimates of contract bundling activity from 1992–2001, the numbers of annual bid protests filed were compared to the numbers of bundling actions previously estimated (Eagle Eye Publishers 2002) for each of the same years. The first comparison was a simple gap analysis where the 10-year totals of each data set were compared and the gap—both numerical and percentage difference between the two values—was calculated.

The second analysis was the measurement of correlations between the two variables: the Eagle Eye Publishers (2002) estimates of the numbers of new bundled contracts by year from 1992–2001 (independent variable) and the number of contractor bid protests filed over the practice for each of those same years (dependent variable).

A strong positive correlation can be expected between contract bundling actions and the bid protests they provoked. Thus, the validity of the Eagle Eye Publishers (2002) estimates of total contract bundling actions each year from 1992–2001 were tested by measuring the correlation between the pairs of annual actions estimated (Eagle Eye Publishers, 2002) and bid protests filed

Three different correlation measurements were computed. Pearson’s correlation coefficient was computed using the numeric values of both the independent and dependent variables. A second Pearson’s coefficient was computed using the square root of the dependent variable to compensate for potential distortions in results due to small relative values and non-normal distribution of the Y data set. The third correlation measurement computed was the Spearman rank correlation coefficient for the original X and Y data sets. For purposes of this study, the measurements of correlation were used only as descriptive statistics, not to develop predictive models.

OVERSTATEMENT IN PRIOR STUDIES

Content analysis was performed to identify potential flaws in construct that might have produced overstated estimates of contract bundling frequency in the Eagle Eye Publishers (2002) study entitled *Impact of Contract Bundling on Small Business 1992–2001*. Analysis focused on the selection criteria used to identify presumptively bundled contracts for inclusion into the population of contract records from which regression analysis developed estimates of bundling frequency. A table was prepared listing the defining characteristics of the statutory definition of contract bundling and

the key elements of the selection criteria used in the Eagle Eye Publishers (2002) study to facilitate a comparative analysis.

VERIFICATION OF VENUE FOR PROTEST FILINGS

To test the possibility that an alternate venue might exist for bid protests filed over the practice of contract bundling, full-text keyword searches were performed on archives of cases heard at several alternative dispute resolution venues—buying agencies, the Army Materiel Command, federal district courts, etc. The absence of cases discovered in these screenings satisfied the study that the U.S. Government Accountability Office bid protest process was the venue where contract bundling bid protests would have been heard and adjudicated.

RESULTS

The central discovery of the study was that only 25 contractor bid protests were filed with the U.S. Government Accountability Office over the practice of contract bundling from 1992 to 2004. The annual number of cases ranges from zero to four with no apparent trend pattern (Table 1). The counts at each step of the selection process were:

1. Documents retrieved in keyword search = 78
2. Duplicates = 24
3. Irrelevant = 30
4. One additional case was discovered that was not returned in the initial keyword search, bringing the total number of cases to 25 (78 – 24 – 30 + 1)

COMPARISON TO ESTIMATED BUNDLING ACTIONS

During the 10-year period from 1992–2001 in which Eagle Eye Publishers reported over 34,221 new bundled contracts and over 106,000 total bundling actions, only 18 contractor bid protests were filed. Table 1 displays the numbers of bid protests filed versus the numbers of new bundled contracts as estimated by Eagle Eye Publishers (2002) for each year 1992–2001.

PROPORTION OF ALL BID PROTESTS

Bid protests filed over bundling from 1995–2004 made up less than 16/100 of 1 percent of all protests filed by contractors over the same period. Table 2 displays the numbers of bid protests filed over contract bundling and total number of bid protests filed from 1995–2004.

SORT-RANKING PROTEST GROUNDS

In the sort-ranking of 15 bid protest grounds, bundling ranked last (15th) returning less than half of the document hits as the number 14th ranked pleading. Results of this sort-ranking are displayed in Table 3.

TABLE 1. BUNDLING ACTIONS ESTIMATED AND CONTRACTOR BID PROTESTS FILED 1992–2001

Fiscal Year	Estimated Actions	Protests Filed
1992	3,920	0
1993	3,378	1
1994	3,203	0
1995	3,427	2
1996	3,400	4
1997	3,282	2
1998	3,287	2
1999	3,272	3
2000	3,356	3
2001	3,687	1
Total	34,221	18

TABLE 2. RATIO OF BUNDLING PROTESTS TO ALL PROTESTS 1995–2004

Year	All Protests	Bid Protests	Ratio
1995	2,529	2	0.079%
1996	2,286	4	0.175%
1997	1,852	2	0.108%
1998	1,566	2	0.128%
1999	1,290	3	0.233%
2000	1,220	4	0.328%
2001	1,146	1	0.087%
2002	1,204	1	0.083%
2003	1,352	3	0.222%
2004	1,387	3	0.216%
Total	15,832	25	0.158%

GAP ANALYSIS

A simple gap analysis was performed comparing the number of estimated new bundled contracts issued (Eagle Eye Publishers, 2002) to the number of contractor bid protests filed for each year 1992-2001. The numeric gap, estimated bundling actions less contractor bid protests is: $34,221 - 18 = 34,203$. The gap percentage—numeric gap divided by estimated bundling actions—is 99.94%.

The gap between 14,865 contractors estimated to have withdrawn from contracting—the 56% reduction expressed in numeric terms—due to bundling and the 18 bid protests filed by contractors is 14,847 or 99.897%.

CORRELATION MEASUREMENT

Using the 10-year numbers for estimated new bundled contracts (Eagle Eye Publishers, 2002) and bid protests as shown in Table 1 for the X and Y data sets, respectively, the resulting Pearson's correlation coefficient was computed: $r = -0.40$. Using the same X data (estimated bundling actions) but using the square roots of the bid protest numbers for the Y data, the resulting Pearson's correlation coefficient was computed: $r = -0.41$. Using the original data sets for both X and Y (Table 1), the Spearman rank correlation coefficient was computed: $r_s = -0.19$.

TABLE 3. SORT RANKING OF BID PROTESTS

	Protest keyword	Hits
15	bundling	96
14	sole source	227
13	commercial items	248
12	foreign owned / sourced	379
11	bid deadline	437
10	price evaluation	457
9	certification	743
8	cancellation of solicitation	857
7	low bid	1,214
6	set-aside	1,408
5	best value	1,585
4	amendment	1,914
3	technical evaluation	1,984
2	past performance	2,345
1	specifications	2,814

TABLE 4. COMPARISON OF BUNDLING STATUTORY
DEFINITION LANGUAGE TO EBC CRITERIA

Definition Element	Statutory Language	SBAOA EBC Criteria
Requirements previously purchased separately	Yes	No
Previous contracts were suitable for small business	Yes	No
New bundled contract is unsuitable for small business	Yes	No
Size threshold for “substantially bundled”	\$10mm	\$1mm
Multiple place of performance	Only if unsuitable	Yes
Multiple product/service codes	No	Yes
Size of contract	Only if unsuitable	Yes
Contract changes over time	No	Yes

EAGLE EYE PUBLISHERS SELECTION CRITERIA

Examination of the methodology of the government’s principal bundling study (Eagle Eye Publishers, 2002) revealed that the selection criteria used to identify bundled contracts is inconsistent with the statutory definition of contract bundling. The defining elements of contract bundling were found to be absent in the selection criteria; conversely, the key elements of the selection criteria were found to be absent in the statutory definition of bundling (Table 4).

DISCUSSION

The Nerenz (2006) dissertation research theory was that the government’s prior estimates of contract bundling frequency and effect (Eagle Eye Publishers, 2002) were materially overstated. Its hypothesis was that the number of contractor bid protest cases filed over the practice of bundling would be insufficient to validate the government’s prior estimates of bundling frequency and effect on small business.

The dissertation findings clearly supported this theory and hypothesis; in fact,

the gap between estimated and protested bundling actions was much larger than was anticipated when the study was conceived.

The finding of only 18 bid protests filed by contractors over the practice of bundling from 1992–2001 sharply contradicts government estimates of 34,221 new bundled contracts awarded and 14,865 firms forced out of the marketplace (Eagle Eye Publishers, 2002) over the same period. The widely held belief that contract bundling is the No. 1 problem facing small businesses in government contracting is refuted by the results of sort-ranking by protest volumes, where bundling ranked last of 15 protest grounds tested (Table 4). With nearly 1,600 bid protests filed per year from 1995–2004 (Table 2), contractors were clearly not reticent about appealing procurement actions that were perceived to be improper, yet the average annual number of bid protests filed over contract bundling during the same 10-year period was less than three.

Analysis of the bundling protests filed showed the success rate for bundling protests to be nearly 10 times the average for all protests (Gamboa, n.d.), so pragmatism alone would not explain the required reticence on the part of small businesses harmed by improper bundling actions.

NEW QUESTIONS RAISED BY THE RESEARCH

Given the low number of bid protests filed by contractors over the practice of contract bundling, continued acceptance of the SBA estimates of bundling actions would require a belief that contractors adversely impacted by the practice would fail to appeal it, even when dire economic consequences ensue. It is not at all clear why contractors would act against their own best interests and waive their rights to appeal through the GAO bid protest process.

The discovery of the Hayes (1999) Congressional testimony that only a handful of bundling actions were lawfully undertaken in FY 1998 raises an even more fundamental set of questions: why would government contracting officers engage in wholesale improprieties and illegally bundle contracts in the first place? Why would these improprieties not have been prosecuted? How could they have avoided detection by Congressional oversight? How could misconduct on this scale be covered up for 15 years or more?

The need for a complex theory to explain all of these new questions only arises if one continues to accept the estimates of bundling frequency reported in prior government studies (Eagle Eye Publishers, 2002). If the SBA estimates were overstated, as the dissertation findings indicate, then no such complex theory development is required. The simplest explanation for the lack of bid protests is the lack of improper bundling activity to be protested. This explanation comports with all of the findings of the dissertation.

GOVERNMENT ESTIMATES OVERSTATED

The dissertation did not merely support its theory that prior estimates of bundling frequency were materially overstated with new and conflicting data; it identified the specific cause of overstatement in prior studies—faulty selection criteria used by

Eagle Eye Publishers (2002) to identify presumptively bundled contracts. The Eagle Eye Publishers (2002) study used the term Explicitly Bundled Contracts, or EBC, to differentiate its selection criteria from the statutory definition of the term bundled contract. Comparison of the Eagle Eye Publishers (2002) selection criteria to the statutory definition of contract bundling (Federal Register §13 C.F.R. Pt. 125) shows the two to be unrelated. None of the key elements of the statute are reflected in the selection criteria, and neither are any of the key elements of the selection criteria found in the statute (Table 4).

The methodology notes state explicitly that the study substituted its own notion of contract bundling for the statutory definition (Eagle Eye Publishers, 2002, p. 59), which it elsewhere described as “self-limiting and unreasonably small” (Eagle Eye Publishers, 2002, p. 15). The study also justified its deviation from the accepted definition of bundling on pragmatic grounds:

It would be impossible with any reasonable amount of resources to do a government-wide study and to either (1) construct a genealogy of contracts so that contracts that were previously separate could be identified, or (2) make judgmental evaluations of contracts to identify all the contracts that had become unsuitable for small business. (Eagle Eye Publishers, 2002, p. 54).

Since the definition of the term contract bundling contains only two defining characteristics—a) requirements combined were previously bought separately, and b) the combined requirements make the new bundled contract unsuitable for small business (13 C.F.R. Pt. 125)—a selection criteria that ignores both elements is certain to produce an unreliable population of bundled contracts from which to develop an understanding of bundling frequency and effect.

Its own results provide the most potent evidence of a contaminated population: the Eagle Eye Publishers (2002) study states that 52 percent of its bundled contracts were awarded to small businesses (Eagle Eye Publishers, 2002). Since one of the two defining characteristics of a bundled contract is that is “unsuitable for small business” (13 C.F.R. Pt. 125), any contract won by a small business is clearly not suitable for bundling. Thus, more than half of the population of contracts in the Eagle Eye Publishers (2002) bundling study was selected in error.

Since the Eagle Eye Publishers (2002) selection criteria do not test for the other defining characteristic of a bundled contract—requirements previously purchased separately—determining whether any of the selected contracts was, in fact, bundled is not possible. Closer examination reveals another possible reason for the award of the remaining 48% of “bundled” contracts to large businesses. The Eagle Eye Publishers (2002) study states that 38% of government contracts go to large firms in the normal course of contracting, and there is no reason to suspect that its selection criteria would not produce a similar proportion in its “bundled” contract population.

CONCLUSIONS

For more than the past decade, the belief that contract bundling was one of the most important barriers to small business participation in government contracting has been universal. This belief was based upon prior government estimates of bundling frequency and effect that were directly contradicted by the findings of new research described in this article. The dissertation's findings describe contract bundling as a rare and isolated activity, a matter of little significance in the development of business strategy and small business advocacy within the realms of public policy development.

The Nerenz (2006) dissertation findings introduced an anthropological dimension to the issue of contract bundling that had not previously been prominently considered: the findings of prior studies (Eagle Eye Publishers, 2002) can only be accepted if theories are developed to explain why government contracting officers would engage in wholesale improprieties, and why small businesses would accept dire economic consequences without exercising their rights to appeal.

The research suggests that public policy resources have been disproportionately directed to the issue of contract bundling, and that resources can safely be redirected to other more important barriers to small business participation. Likewise, small business strategies designed to defend against a major threat of bundling should be re-examined in light of a more realistic assessment of the threat posed by the practice.

Finally, the study demonstrates the usefulness of GAO bid protest archives as a source of information about federal procurement practices and their impact on small businesses that contract with the federal government. The methods used in this study could be applied to many other issues of interest to the contracting community, policy makers, and small business advocates.



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TRANSLATED GLOBAL POSITIONING SYSTEM RANGE SYSTEM TRADE STUDY

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The Translated Global Positioning Systems Range System (TGRS) is currently in production and is being used at most relevant Department of Defense missile ranges. The Enhanced-Translated Global Positioning System Range System (E-TGRS) was ultimately designed and prototypes built to replace the TGRS. However, the E-TGRS was cancelled due to budget constraints. In light of these events, the purpose of the trade study presented in this article is to recommend selection of one alternative based on the comparison of benefits and cost of three alternatives: continue with TGRS as is, perform upgrades to TGRS, or reinstate E-TGRS to replace TGRS.

The Translated Global Positioning System Range System (TGRS) is part of a compatible family of equipment designed to provide Time-Space-Position Information (TSPI) for low- and high-dynamic participants in Department of Defense (DoD) test, training, and operational ranges. TGRS provides the capability for real time line-of-sight (LOS) tracking and recording of high-quality pre-track Global Positioning System (GPS) signals, which are a primary source of target and interceptor post-mission independent truth data, position and velocity, and real time flight safety track.

TGRS consists of two primary subsystems, which include the Digital GPS Translator (DGT) that is placed on the airborne vehicle and the GPS Translator Processor (GTP) that is the ground segment. The DGT receives the L-band signal from available satellites, translates it to the S-band, and transmits the S-band signal to the GTP. The GTP receives the S-band signal from the DGT and processes the data.

TGRS began development in 1996 and production in 2001. The engineering design is based on 10-year-old technology resulting in questionable capability to

meet future deployment needs. To reduce risks, the future system needs to be more efficient and flexible with better performance and lower costs. In addition, many parts of the current TGRS are becoming obsolete, which will eventually lead to failure to meet future production needs.

E-TGRS was designed to be the next generation of TGRS, offering enhanced performance capabilities at a cheaper cost. E-TGRS development started in 2003 to replace TGRS, but was canceled in October 2005 due to lack of funding. E-TGRS also consists of two primary subsystems which include the Enhanced Digital GPS Translator (EDT) to replace the DGT and the Enhanced GPS Translator Processor (E-GTP) to replace the GTP.

One possibility to consider is performing upgrades to the existing TGRS, which would address only the immediate, short-term concerns about the system. These upgrades would mostly involve replacing key components in the system but would require some research and redesign work to be done. However, concern has been expressed that the upgrades would only be a temporary fix instead of addressing the root problems of the system.

Interstate Electronics Corporation (IEC), the prime contractor for design and manufacturing of TGRS and E-TGRS, is located in Anaheim, California. IEC has provided nonrecurring engineering (NRE) and recurring engineering (RE) cost estimates for both the upgrades and for the completion of E-TGRS.

TRADE STUDY METHODOLOGY

The following is an overview of the trade study process used in this analysis. Each of these steps is detailed in the sections immediately following.

1. **Background:** The problem, decision context, decision makers, time frame, project life, interest rate, and constraints are defined.
2. **Objectives:** Once the objectives are defined and ranked, the weighting for each objective is calculated using an appropriate method.
3. **Alternatives Identified:** The alternatives to be evaluated are identified and defined.
4. **Benefits Score:** Each alternative is evaluated against each objective by narrative description and by numerical score. A total value of benefits score is calculated for each alternative.
5. **Cost Model:** A model for economical cost analysis is developed to obtain a cost estimate for each alternative. Monte Carlo simulations are performed on the subjective cost estimates for each alternative.
6. **Sensitivity Analysis:** Sensitivity analysis is performed on the alternative selection. Although a well-defined process for doing sensitivity analysis does not exist, the sensitivity analysis should be robust enough to provide confidence to the decision makers that the best decision is being recommended.

7. Conclusions and Recommendations: A benefits-to-costs plot is constructed to obtain a visual aid that combines the total value of benefits score and estimated cost for each alternative. Conclusions and recommendations are presented based on the benefits-to-costs plot.

BACKGROUND

The purpose of the trade study presented in this article is to recommend a selection of the best alternative based on the comparison of benefits and cost of TGRS, upgrades to TGRS, and E-TGRS. TGRS will play a very important role for the next several years in DoD testing of airborne vehicles. Management should place emphasis on planning for future GPS needs and ensure the proper capabilities and resources are available at a reasonable cost. The project life used for this study is 5 years because flight test plans are initiated 5 years in advance, and TGRS will be a required test asset for at least 5 more years. The annual interest rate used for this cost analysis was 8 percent, which is traditionally used for independent government cost estimates for this agency. This rate compares well with Office of Management and Budget (OMB) guidance found in Circular A-94, which calls for proposed investment and regulatory changes to be evaluated using a 7 percent discount rate (OMB Circular A-94, 1992). Flight test program offices were surveyed, and it was determined that the projected number of units needed for the 5-year study period are 11 GPS Translator Processors (GTPs) and 148 DGTs. The decision makers for this trade study are the program manager of TGRS and the director of the Directory of Test Resources. The results of the analysis will be presented to upper management within the Missile Defense Agency (MDA) for final selection and approval of funding. The decision must be made in early FY 2007 to allow for long-lead procurements.

OBJECTIVES

The objectives of the GPS system were obtained via numerous working group meetings with subject matter experts. The subject matter experts helped to identify and define areas of concern for the current TGRS program. The working groups focused on key objectives that if not met may lead to failure to support future missions for the next 5 years. The group also considered objectives that would benefit the performance of the system but are not as critical as others. Therefore, the rank sum method was used to give the weights a linear decrease as the rank importance decreases. E-TGRS or any upgrades to the current TGRS must meet or outperform the interface and performance requirements as specified in the Interface Control Document for the GTP Subsystem of TGRS (Interface Control Document 36900002, 2003) and the Interface Control Document for the DGT Subsystem of TGRS (Interface Control Document 36900001, 2004). Figure 1 provides a summary of the objectives, the ranking, and the weighting for each objective.

The rank sum method was selected to weight objectives because the team had exhibited a high degree of consistency in their discussions concerning the objectives. This method also limited the cognitive burden on the decision makers. Other approaches, such as pair wise comparison, can be used when there is less agreement on the relative priority of objectives; however, care should be taken to address inconsistencies in decision-maker preferences (Gholston, 1999).

First, rank the objectives and place them in descending order starting with the most important. Second, create a column for the inverted rank of each objective. For example, assume you have five objectives. The highest objective, objective No. 1, would have an inverted rank of 5; the second highest objective, objective No. 2, would have an inverted rank of 4, and so on. Third, sum up the column of inverted ranks (i.e., $5+4+3+2+1 = 15$). Last, divide the inverted rank for each objective by the sum of the column of inverted ranks. In our example, the weight for objective No. 1 would be $5/15 = 0.333$, the weight for objective No. 2 would be $4/15 = 0.267$, and so on.

Down-link bandwidth–Real Time objective refers to the amount of bandwidth the systems require when transmitting the data from the airborne unit to the ground unit. Requiring a large amount of bandwidth adds risk to the program because a possibility exists that the upper S-Band frequencies may not be available in the future. Currently, the system can operate at either 8 MHz. or 4 MHz.

FIGURE 1. OBJECTIVES, RANK, AND WEIGHT

Objectives	Rank	Weight
Down-Link Bandwidth Required - Real Time	1	16.7%
Down-Link Bandwidth Required - Post Mission	2	15.2%
Production Lead Time	3	13.6%
Modular	4	12.1%
Encryption	5	10.6%
DGT/EDT Power Consumption	6	9.1%
DGT/EDT Weight and Size	7	7.6%
High Dynamics	8	6.1%
Plume Effects	9	4.5%
TTFF	10	3.0%
Design Schedule	11	1.5%

Down-link bandwidth–Post Mission objective refers to the level of fidelity needed in the post-mission data. While lowering the required amount of bandwidth is desired, higher bandwidths allow for a higher data transfer rate that can be used to create more detailed post-mission data.

Production lead time refers to the amount of time it takes to produce a system once an order has been placed. Production lead time is strongly influenced by the availability of parts needed to produce the system. Modular refers to the capability of interchanging components in the field to customize the system for each individual test. Modularity adds flexibility to better serve the needs of each individual project office.

Encryption refers to the capability to encrypt the data transmitted from the DGT unit to the GTP unit, which is required for some tests. Encryption capability can be designed with different types of encryption chips. However, the design must be approved by the National Security Agency (NSA).

Power consumption refers to the amount of power that is required to operate the DGT. The current requirement is 50 watts or less.

Weight and size of the DGT are important because the spaces and weight requirements for most airborne vehicles are very restrictive. These requirements vary depending on the specific vehicle.

High dynamics refers to the flight characteristics the airborne vehicle endures. The GPS system must be able to accurately track the vehicle even during high accelerations. The airborne unit must be able to withstand at least 75g per second.

Plume effects refer to the degradation of signal level caused by plume the vehicle causes during flight. The TGRS system must have the ability to track the vehicle through the plume. Tracking through plume effects plays an important role in safety to ensure the vehicle is not significantly off course.

Time to First Fix (TTFF) refers to the amount of time it takes the system to acquire the airborne vehicle immediately after launch. TTFF also plays an important role in safety to ensure the vehicle is not significantly off course.

Design Schedule refers to the amount of time needed to complete design work and any necessary qualification testing. Long design schedules add risk to meeting future requirements.

ALTERNATIVES IDENTIFIED

Over the last few months several discussions have occurred, and currently three alternatives are being considered. Alternative 1 is to continue with the current TGRS design as is and accept the risk associated with not meeting future deployment needs. The purpose for keeping this high-risk alternative is to provide a basis for comparison to other alternatives. Alternative 2 is to add upgrades to the current TGRS system including: new S-Band Converter (SBC) switch, 5 MHz. filter on the SBC, replace obsolescent Fiber Channel Data Acquisition Card (FCDAC), upgrade Pre-Track

Signal (PTS) recorder, replace data archive unit (DAU), and replace the GTP Tracker Controller. Alternative 3 is the E-TGRS, which consists of the Performance Enhanced Tracker (PET) Board that would be placed in the E-GTP unit and the EDT.

BENEFITS SCORE

Each alternative was evaluated against each objective by narrative description and by numerical score. One subject matter expert used for this evaluation is the TGRS program manager, who currently works as a civilian for the Missile Defense Agency. He has been working the TGRS program since it was initiated over 10 years ago. The other two subject matter experts were personnel from GRAY Research, one who has also been with the program for over 10 years and the other for over 5 years. The narrative evaluation, shown in Figure 2, gives a brief description of the advantages or disadvantages of each alternative with respect to each objective. The numerical score ranged from poor, which was scored as a “1” to excellent, which was scored as a “5,” and the numerical score evaluation for each alternative is shown in Figure 3. Figure 4 shows the weighted evaluation results for each alternative. The bottom row of Figure 4 is the sum of the benefits for each alternative. These numbers are relative rather than absolute. Alternative 2 offers approximately 71 percent of the total benefits that Alternative 3 offers. Likewise, Alternative 1 offers approximately 60 percent of the total benefits compared to Alternative 3.

COST MODEL

Cost modeling was performed to reduce the risks associated with subjective cost estimating. The first step was to create present value cost estimates for each FY based on NRE and RE estimates of each alternative and the projected number of GTPs and DGTs required for FY 2007 through FY 2011. Next, subjective probability functions were estimated for each alternative, shown in Figure 5. All probability functions were elicited from the TGRS program manager and a contractor who supports the management of the program and has been with the program for over 10 years. Finally, a Monte Carlo simulation was performed on the probability functions with 30 simulations in order to utilize the Central Limit Theorem. Three hundred iterations were performed on each simulation in order to aim for a convergence level of 1.5 percent. Figure 6 shows the summary results of the Monte Carlo simulation, which are the average and standard deviation of the means for the 30 simulations performed on each alternative. The variance of each set of 30 simulations was relatively small for each alternative. A summary of relevant cost data is provided in the appendix.

Some assumptions were made in order to create a realistic cost model.

1. All units are ordered in the previous FY to meet the following year's flight requirements. This will allow for production lead times.
2. The costs occur at the end of the FY at the same time the order is placed.

3. If Alternative 3 (E-TGRS) is to be selected, DGTs would be used for FY 2007 until E-TGRS could be developed and slowly phased into operation.
4. Current operational GTPs and DGTs would be sufficient until Alternative 3 (E-TGRS) was developed and tested.
5. Alternatives 1 (TGRS) and 2 (Upgrades) would use existing DGTs as is.
6. NSA Certification Costs could be spread over a period up to 3 years. However, all NSA Certification Costs were treated as initial costs.

FIGURE 2. NARRATIVE EVALUATION

Objectives	Alternative 1. TGRS	Alternative 2. Upgrades	Alternative 3. E-TGRS
Down-Link Bandwidth Required - Real Time	Requires 4 MHz.	Requires 4 MHz. but gives a little more control over where frequencies can be set.	Requires 200 KHz.
Down-Link Bandwidth Required - Post Mission	Provides detailed data for post mission analysis.	Provides detailed data for post mission analysis.	Less data collected but is sufficient to do some analysis.
Production Lead Time	12 month lead time for DGTs. Parts are hard to find for GTPs.	12 month lead time for DGTs. Parts for GTPs would be easier to get.	6 month lead time for EDTs. Parts would be commercial off the shelf for PET Board.
Modular	Translator only. Encryption is factory set. Only 1 power setting.	Translator only. Encryption is factory set. Only 1 power setting.	Translator or Receiver. Encryption module can be added in the field. High or low power module.
Encryption	Old encryption chips.	Old encryption chips.	New chips are faster and smaller. May be easier to get NSA certification.
DGT/EDT Power Consumption	50 W. Loses 6 dB when operating in encryption mode.	50 W. Loses 6 dB when operating in encryption mode.	50 W or 5 W for GPS Receiver only. Does not lose 6 dB in encryption mode.
DGT/EDT Weight and Size	13 oz. 12 in ³	13 oz. 12 in ³	16 oz. for EDT or 3 oz. if using GPS Receiver only. 22 in ³ for all modules or 3 in ³ for GPS Receiver only.
High Dynamics	75 g/s	75 g/s	> 200 g/s
Plume Effects	Susceptible	Susceptible	Minimal
TTF	Cannot meet the 1 sec. TTF	Cannot meet the 1 sec. TTF	Better than 1 sec. TTF.
Design Schedule	Already designed.	No prototypes built and tested.	Prototypes have been built but have not been through qualification tests.

SENSITIVITY ANALYSIS

Although the trade study appears to be very robust, a simple sensitivity analysis was performed on the performance results.

Lowering the numerical score evaluation by 1 point for each objective for Alternative 3 (the preferred alternative) leads to a total benefits score of 2.97, which is still higher than Alternatives 1 and 2.

Likewise, leaving Alternative 3 as is and increasing the numerical score evaluation by 1 point for each objective leads to a total benefits score of 3.41 for Alternative 1 and 3.42 for Alternative 2. Both of these values are still lower than the 3.97 value originally obtained for Alternative 3.

CONCLUSIONS AND RECOMMENDATIONS

The trade study methodology was followed to provide a defensible, logical, and structured selection. The results of the trade study are that E-TGRS has a much

FIGURE 3. NUMERICAL SCORE EVALUATION

Objectives	Rank	Weight	Alt. 1 TGRS	Alt. 2 Upgrades	Alt. 3 E-TGRS
Down-Link Bandwidth Required - Real Time	1	16.7%	1	2	5
Down-Link Bandwidth Required - Post Mission	2	15.2%	5	5	3
Production Lead Time	3	13.6%	1	3	4
Modular	4	12.1%	2	2	4
Encryption	5	10.6%	2	2	4
DGT/EDT Power Consumption	6	9.1%	2	2	5
DGT/EDT Weight and Size	7	7.6%	3	3	2
High Dynamics	8	6.1%	4	4	5
Plume Effects	9	4.5%	1	1	3
TTFF	10	3.0%	4	4	5
Design Schedule	11	1.5%	5	3	2

FIGURE 4. WEIGHTED EVALUATION RESULTS

Objectives	Rank	Weight	Alt. 1 TGRS	Alt. 2 Upgrades	Alt. 3 E-TGRS
Down-Link Bandwidth Required - Real Time	1	16.7%	0.17	0.33	0.83
Down-Link Bandwidth Required - Post Mission	2	15.2%	0.76	0.76	0.45
Production Lead Time	3	13.6%	0.14	0.41	0.55
Modular	4	12.1%	0.24	0.24	0.48
Encryption	5	10.6%	0.21	0.21	0.42
DGT/EDT Power Consumption	6	9.1%	0.18	0.18	0.45
DGT/EDT Weight and Size	7	7.6%	0.23	0.23	0.15
High Dynamics	8	6.1%	0.24	0.24	0.30
Plume Effects	9	4.5%	0.05	0.05	0.14
TTFF	10	3.0%	0.12	0.12	0.15
Design Schedule	11	1.5%	0.08	0.05	0.03
		=	2.41	2.82	3.97

FIGURE 5. SUBJECTIVE PROBABILITY FUNCTIONS
FOR COST OF EACH ALTERNATIVE

Type of Cost	Probability Functions		
	Alternative 1 (TGRS)	Alternative 2 (Upgrades)	Alternative 3 (E-TGRS)
NSA Certification Cost	P(\$1M) = 0.5; P(\$0.667M) = 0.3; P(\$0.333M) = 0.2	P(\$1M) = 0.5; P(\$0.667M) = 0.3; P(\$0.333M) = 0.2	P(\$1M) = 0.25; P(\$0.667M) = 0.3; P(\$0.333M) = 0.45
Initial Cost	Certainty Initial Cost of \$00	N(\$4,165,000, \$75,000)	N(\$1,763,300, \$50,000)
FY 07 Cost	N(\$4,590,000, \$400,000)	N(\$5,175,000, \$400,000)	N(\$3,956,700, \$300,000)
FY 08 Cost	N(\$1,740,000, \$400,000)	N(\$1,740,000, \$400,000)	N(\$725,000, \$300,000)
FY 09 Cost	N(\$3,610,000, \$500,000)	N(\$3,675,000, \$500,000)	N(\$1,731,300, \$400,000)
FY 10 Cost	N(\$3,010,000, \$500,000)	N(\$3,075,000, \$500,000)	N(\$1,481,300, \$400,000)

higher benefits value and is also much cheaper over the 5-year study period. However, information should continue to be collected and evaluated over the next few weeks to reduce some of the uncertainties in the trade study. The current recommendation is to continue with TGRS through FY 2007 in parallel with completing development and testing of E-TGRS to begin production at the end of FY 2008.

FIGURE 6. COST SIMULATION RESULTS

Alternative	Average Mean Output	Standard Deviation
1. TGRS	\$11,586,669	\$1,141
2. Upgrades	\$16,392,675	\$1,319
3. E-TGRS	\$9,111,763	\$813

APPENDIX

RECURRING ENGINEERING (RE) COSTS PER UNIT

Description	Cost
RE Cost per GTP	\$370,000
RE Cost per DGT	\$60,000
RE Cost per GPT with Upgrades	\$435,000
RE Cost per E-GTP	\$381,300
RE Cost per EDT	\$25,000

NUMBER OF UNITS PER FISCAL YEAR

Projected # of Units	FY 2007	FY 2008	FY 2009	FY 2010	TOTAL
GTP or E-GTP	9	0	1	1	11
DGT or EDT	21	29	54	44	148

TOTAL COSTS PER ALTERNATIVE MINUS
NATIONAL SECURITY AGENCY (NSA) COSTS FOR EXISTING UNITS

Existing Units				
		Nonrecurring Engineering (RE)	Recurring Engineering (RE)	
Translated Global Positioning System Range System (TGRS)	GTP	\$0	\$0	
	DGT	\$0	\$0	
GTP Upgrades	S-Band Converter (SBC) Switches & 5 MHz Filter	\$350,000	\$410,000	
Fiber Channel Data Acquisition Card VME (Bus) Card		\$500,000	\$1,025,000	
Pre-Track Signal (PTS) Recorder		\$100,000	\$410,000	
Data Archive Unit (DAU)		\$250,000	\$205,000	
GTP Tracker Controller		\$300,000	\$615,000	
E-TGRS	E-GTP	\$650,000	\$463,300	
	EDT	\$650,000	\$0	
Projected Units for FY 2007 - FY 2011				
		Nonrecurring Engineering (RE)	Recurring Engineering (RE)	
Translated Global Positioning System Range System (TGRS)	GTP	\$0	\$4,070,000	
	DGT	\$0	\$8,880,000	
GTP Upgrades	GTPs	\$0	\$4,070,000	
	DGTs	\$0	\$8,880,000	
SBC Switches and 5 MHz Filter		\$0	\$110,000	
FCDAC		\$0	\$275,000	
PTS Recorder		\$0	\$110,000	
DAU		\$0	\$55,000	
GTP Tracker Controller		\$0	\$165,000	
E-TGRS	E-GTP	\$0	\$4,194,300	
	EDT	\$0	\$3,700,000	
		Nonrecurring Engineering (RE)	Recurring Engineering (RE)	TOTAL
Alternative 1		\$0	\$12,950,000	\$12,950,000
Alternative 2		\$1,500,000	\$16,330,000	\$17,830,000
Alternative 3		\$1,300,000	\$8,357,600	\$9,657,600



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STRATEGIC MODEL FOR THE ARMY NATIONAL GUARD NETWORK TRANSFORMATION

LTC (P) Robert E. Banks, (TxARNG), and
Maj Clayton Duncan, USAF

Defense acquisition policy directs all participants in the acquisition system to recognize the reality of fiscal constraints and to view cost as an independent variable. By direction, "Milestone Decision Authorities (MDAs) are to identify the total costs of ownership and, at a minimum, the major drivers of total ownership costs." This article describes an Information Technology (IT) Modernization Strategic Driver Model, applies it to the modernization efforts of Army National Guard (ARNG) Joint Force Headquarters (JFHQ) Wide Area Network (WAN), and analyzes the model's impact on accomplishing defense acquisition system policy objectives. The article establishes and supports that a properly developed strategic model permits decision makers to align acquisition program and technical planning to strategic drivers.

"The significant problems we face cannot be solved at the same level of thinking we were at when we created them."

— Albert Einstein

Acquisition and modernization of information technology systems is an uneasy balance for mission support personnel. Those responsible are challenged by the quickened pace of change and dwindling resources for implementation and maintenance. These same rapid technological advancements almost overtook the Reserve Component Automation System (RCAS) program before it was fully implemented and now have stretched the RCAS-deployed IT systems beyond

the operational design capabilities (Brady, 1998). This reinforces the need for military networks to undergo a period of revolutionary or even disruptive rather than evolutionary change, that is, a *Transformation*. Strategic planning for the modernization of the JFHQ WAN would be a vital aspect of the ARNG military network transformation.

The American soldier is empowered in war by new technology, just as information technology has empowered consumers (Vandergiff, 2002). The G6 applications of Information Management (IM) and IT concepts are leading the military's transformation of its networks to increased responsiveness in mission support. These officials are responsible for integrating policy, process, and technology through the initiation, validation, and enforcement of business process re-engineering. However, many well-intended officials do not apply the engineering principles associated with rapidly changing technology. Often, their validations focus on one or two core factors, such as *New Technology* or *Governance*, without also considering the second-order effects of other core factors, such as *Legacy Systems* or *Funding*. The same holds true for third-order effects that involve *Support* or *Services* of the variety of models. This article describes an IT Modernization Strategic Driver Model, as shown in Figure 1, and applies it to the modernization efforts of ARNG JFHQ. This model shows that IT operational core factors' actions can align with the strategic objectives. Decision makers often don't visualize the effects of their network-change decisions from a strategic model viewpoint, nor are they fully aware of the best methodology to achieve strategic IT objectives. This limited perspective

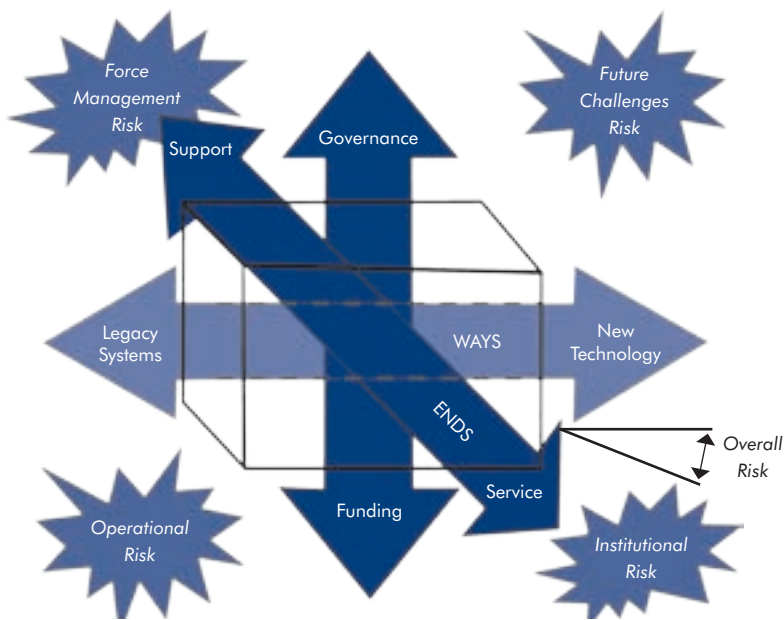


FIGURE 1. INFORMATION TECHNOLOGY MODERNIZATION MODEL

* The ideas represented in this figure are the authors' concept of a strategic model that permits ARNG decision makers to better align actions to achieve strategic Information Technology (IT) objectives.

results in new stovepipe, stand-alone IT platforms and networks, rather than the more robust enterprise network solutions that are truly capable of providing new communication essential *Services*.

To ensure a comprehensive knowledge of more constructive ways to achieve WAN modernizations, we begin with a discussion of the main IT modernization drivers, transformation axioms, and strategy influences. Next, we examine a strategic decision model and offer an Information Technology Modernization Model to balance limited resources among conflicting interests within a strategic IT decision-making framework. We then describe recent practices that highlight the need for a

Decision makers often don't visualize the effects of their network-change decisions from a strategic model viewpoint

better application of the engineering laws to align decisions and actions with strategic IT objectives. Finally, we suggest how personnel at the operational level, who deal with these core factors of network modernization, can exploit technology changes to achieve their strategic IT objectives.

CORE FACTORS

MISSION

The Army National Guard, along with the Active Army and the Army Reserve, are partners in fulfilling the nation's military needs. Due to the Global War on Terrorism (GWOT) and other requirements, the 54 JFHQ WANs of the Guard (one per state/territory) need upgrades and more robust networks to support the essential services to satisfy the command and control, administrative, health, and welfare needs of soldiers both here and abroad. On a broader scale, to effectively engage in the GWOT these ARNG state-level WANs need improved connectivity with other DoD commands and federal government agencies.

SERVICE AND SUPPORT

Clayton M. Christensen, author of *The Innovator's Dilemma*, examined the reasons why many good organizations (companies) fail to remain atop of their industries when confronted with a disruptive market and technological change (Christensen, 1997). Christensen discovered these organizations achieved their leadership when both company officials and their customers became heavily focused on the same objectives. However, Christensen also found businesses tended to optimize and localize current capabilities to obtain short-term gains, rather than take on the challenges of new systems that would yield a more widespread benefit influencing future operations and profitability (Fastabend & Simpson, 2004).

Within most organizations, the role of information technologies and networks has changed and grown; therefore, technology and WAN investments should undergo a similar change. In the past, IT organizations ran effectively as local support functions. However, most new IT applications now span the entire organizational enterprise, and they are an integral part of its operations and support functions. These applications also connect via linked networks to external joint partners and customers (Lohmeyer, Pogreb & Robinson, 2006). Today, IT managers are key team players in the development and delivery of new technology network-based products and services. In an effort to gain competitive edge, IT initiatives are now generally sparked and led by organizational business leaders, and not the IT staff. In an effort to enhance mission success, comply with net-centric key performance parameters, and better leverage senior leader programs, IT refresh, upgrades, and modernization initiatives are driving organizational leader performance demands.

These leaders are trusted to accomplish these strategic goals with limited or redirect allocation and resources. Modernization initiatives and execution designed for customer satisfaction enhance the importance of IT support within the organization and affect their strategic IT goals. In addition to adding capabilities, the associated training cost over several years can exceed the cost of a new IT system. As a result, an organization's proposed IT training budget may be in direct competition with desired technological upgrades. The IT technicians who maintain these systems have perishable skills. If not refreshed via training, these vital human capital assets lose value. Proper force management requires balancing desired institutional services with the training required to sustain a skilled support staff.

NEW TECHNOLOGY AND LEGACY SYSTEMS

Technology is racing ahead, and today's equipment will be considered obsolete in less than 10 years. For example, consider the brief life span of the 1994 Pentium chip and associated desktop computers (Kurzweil, 2003). It took only a few years for the original Pentium systems to be totally outdated, that is, replaced by a series of Pentium I, II, and III upgrades. Such rapid technology changes did not occur 53 years ago when the B-52A first flew in 1954. Today, these same B-52s are one of the few exceptions to obsolescence. These old weapons platforms continue to perform, mostly due to well-planned and -engineered evolutionary upgrades. They delivered 40 percent of all air-dropped explosives during Desert Storm (Air Force Link, October 2005).

Today, the match between process and product continues to shift dramatically. The best organizations use standard application packages for routine tasks; however, they minimize customization of these products. In addition, to ease integration between departments, they keep their network infrastructures as uniform as possible. In these ways, organizations shift spending away from maintaining IT systems and network capabilities. Instead, they move towards developing new applications—these are the ultimate drivers of network-based IT Services and can be used as a measure of an organization's value.

In technology, there are definitions of how things operate, such as Ohm's Law for voltage across a component, and Kirchhoff's Laws for current in a circuit. Additionally, so called "laws" ingrained in mainstream culture aren't really laws at all. Instead, they are folksy rules of thumb. For example, Murphy's Law (first uttered in 1949) said that, "If there are two or more ways to do something and one of those ways can result in a catastrophe, then someone will do it."

One question raised by these rules-of-thumb is the "legitimacy" status. Do these laws merely describe reality or do they create it? Some of these so called rule-of-thumb "laws" have stood out by driving today's technology changes (Ross, n.d.). Present network implementations have not paid sufficient attention to the engineering laws and their combined beneficial or detrimental influences on network modernizations. The most significant of changes applicable to IT and network modernizations are changes in capability, bandwidth, and value as alluded to by these three laws (strategic drivers):

1. Moore's—The number of transistors on a chip doubles annually.
2. Nielsen's—Internet connection speed will grow by 50 percent per year.
3. Metcalfe's—A network's value grows proportionately to the number of its users squared.

MOORE'S LAW

Often referred to as the mother of all "engineering laws/rules of thumb," Moore's Law was suggested in a 1965 Intel Corporation paper (Moore, 1965). Today, this law is

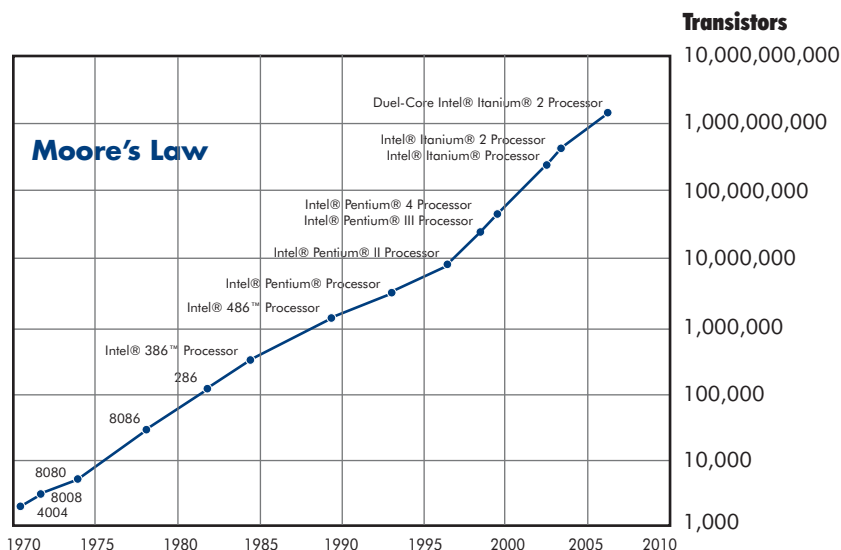


FIGURE 2. INTEL PROCESSOR PERFORMANCE

* Moore's Law Made Real by Intel® Innovation. Retrieved Nov. 15, 2007, from <http://www.intel.com/technology/mooreslaw/index.htm>

integrated into the “road map” of many industries, and is used as a measurement bar to assess corporate achievement. It was Carver Mead of California Institute of Technology, not Moore, who dubbed this rule a “law” many years after Moore’s initial paper.

Clearly, Moore’s Law drives technology’s pace. This implies that DoD acquisition programs and technical strategies must be structured to leverage Moore’s Law as a driver (Department of Defense, DoDD 5000-1, May 12, 2003). Processing power, measured in millions of instructions per second (MIPS), has steadily risen because of increased transistor counts. Figure 2 characterizes this chip-doubling in performance terms, which has impacted IT servers, routers, and switches. Applying this law is equivalent to a requirement for an approximately 60 percent average annual growth in an organization’s IT equipment capability. The second- and third-order effects certainly influence an organization’s acquisition strategies and procurement plans.

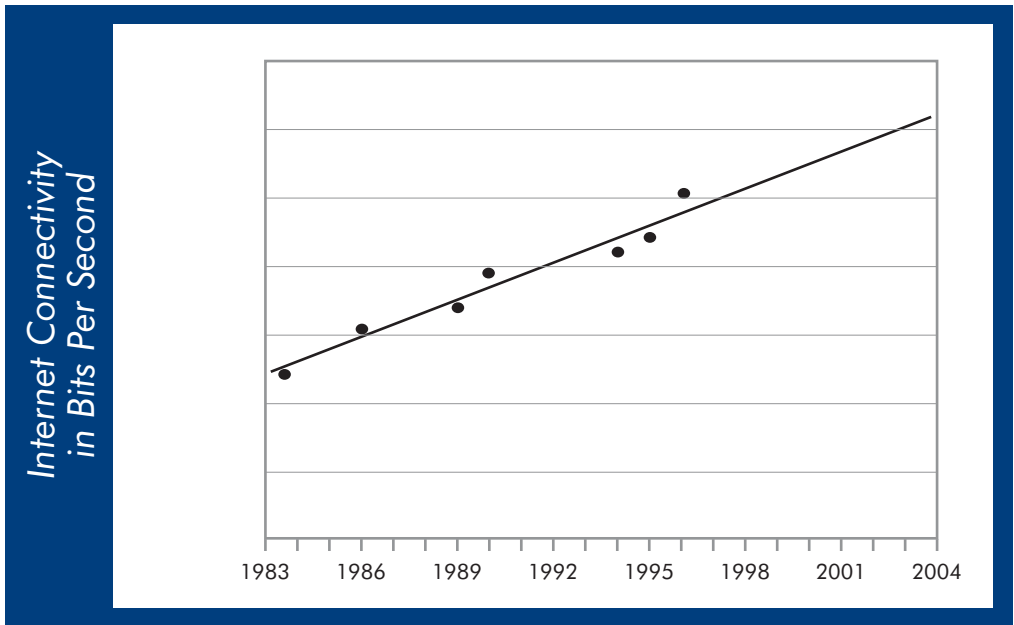


FIGURE 3. NETWORK CONNECTIVITY SPEED

* Nielsen, Jakob. (1998, April 5). Nielsen’s law of Internet bandwidth. *Jakob Nielsen’s Alertbox*. Retrieved March 17, 2006, from <http://www.useit.com/alertbox/980405.html>

NIELSEN’S LAW

Nielsen’s Law deals with bandwidth growth within the Internet. In 1998, Jakob Nielsen, an Internet usability expert, predicted that a high-end user’s Internet connection speed will grow by 50 percent per year (Nielsen, April 5, 1998). This law impacts the *Services* roll-out pace. Figure 3 shows 2001 full T-1 (1,544,000 bps) bandwidth upgrades for GWOT support were surpassed in the following year. Bandwidth available to the user will remain a gating factor in the Internet speed and quality experience, so what’s the organization’s acquisition plan for bandwidth growth?

METCALFE'S LAW

Metcalfe's Law asserts that a network value grows proportionally to the number of users squared. In the 1980s, Robert Metcalfe, founder of Ethernet and 3Com Corporation explained, "Having the one telephone in the world would be of zero value, but this value increases for each new telephone it can call." Applying this law means the value of single JFHQ WAN increases with Internet Protocol (IP) convergence of its current voice, video, and data capabilities with those of other linked IP networks. In 1993, Forbes ASAP maintained Metcalfe's Law would amplify Moore's and, in so doing, remake the world. Do our Acquisition Strategies facilitate technologies' convergence for increased service value?

Instead of adopting a prioritized modular approach for constructing high-value, large-scale networks, decision makers have sometimes opted instead to build isolated new technology WAN solutions, either as showplaces or test beds for the latest IT equipment capabilities. This approach undermines and delays an organization's transition to a larger-scale, more capable enterprise network that benefits many, rather than a few. Similarly, in the long term, attempts to retain existing *Legacy Systems* prove to be equally counterproductive. As stated in Metcalfe's Law, a network that is twice as large, will be four times as valuable, because there are four times as many things that can be done due to a larger number of interconnections. Therefore, larger enterprise-solution networks will always be of greater value than smaller networks, even if these smaller versions have desirable, special-purpose features or benefits (Nielsen, July 25, 1999). The conclusion is that it is far better to invest in enterprise-level network solutions, such as the Global Information Grid (GIG), which will ultimately provide high-speed, all-Command access to the Guard's JFHQ WAN. For the ARNG, this means it should continue to modernize all 54 of its state-level WANs to the new GIG standards and eliminate its *Legacy Systems* in order to become a fully compliant member of the DoD's secure, worldwide GIG network solution.

GOVERNANCE AND FUNDING

Governance ensures decisions are aligned with the overall strategy of an IT enterprise network. It provides guidance and establishes standards and principles for prioritizing and managing investments. However, *Governance* is not a safe haven that averts risk. Rather, risks are identified, assessed, tracked, reported, controlled, transferred, assumed, or mitigated. When decision-maker actions are properly aligned to IT strategic network objectives and the appropriate drivers, they can continue to leverage cost, schedule, and performance metrics for mission success.

IT network investments have the potential to improve lives and organizations. However, if not planned and implemented well, these projects can also become risky, costly, and counter-productive. Portfolio Management (PfM) is a strategy for managing IT capital investment and control (Portfolio Management [PfM] Overview, n.d.). The main benefit of judicious PfM is a more accurate alignment of an organization's network and technology needs to its business goals and missions.

Information technology ease of information access reduces uncertainty; but, IT can also develop redundant processes that require additional efforts for interoperability.

Therefore, IT decision makers must balance these efforts and should concentrate on a limited number of key impact areas and equipment selections that benefit the greater user population. Spending on equipment should also be influenced by adherence to the technology standards of the targeted parent network, such as the Army’s LandWarNet and the DoD’s GIG. “The importance of standards” balances, to some degree, the risks associated with *Legacy Systems* and the estimated needs of future applications.

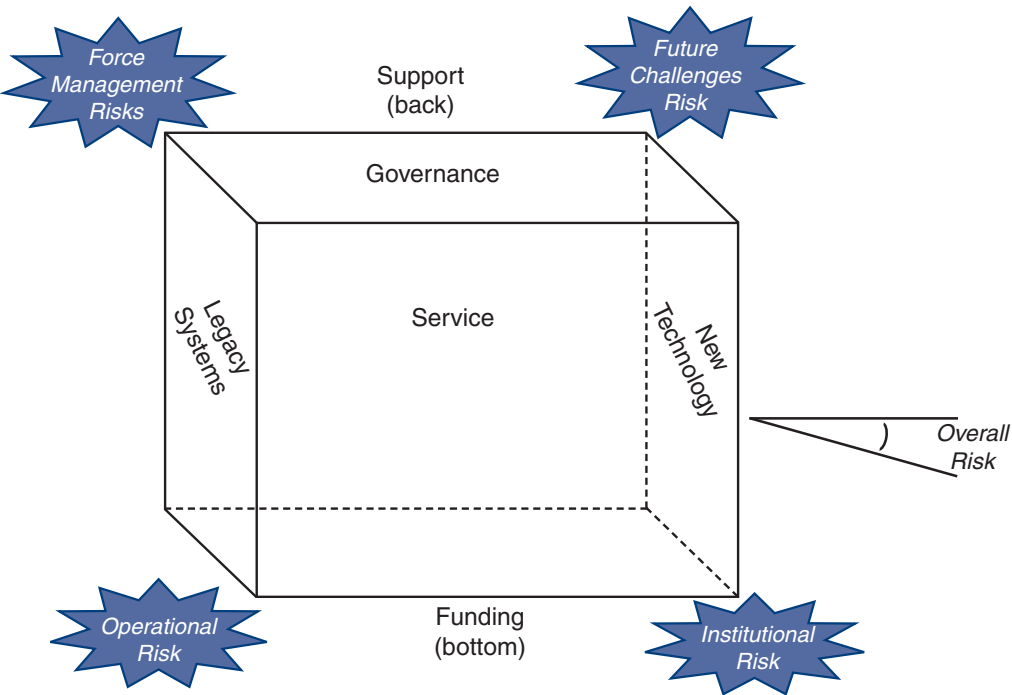


FIGURE 4. CORE FACTORS RISK

* The ideas represented in Figure 4 are based on publicly available sources of risk to link them with IT core factors in the development of the authors’ strategic model.

RISK

Managing risk is central to the new way of thinking within DoD. In a complex enterprise network, it’s essential to assess the risks associated with *IT services and support*, such as those shown in Figure 4. For example, consider the factors involved with institutional risk of *new technology*, which often counter the factors affecting force management risk, that is, the ability to recruit, train, equip, and retain quality personnel. Then, there’s the risk in future challenges, that is, the ability to invest in new services and operational concepts. These should be balanced with the funding and governance of operational risk factors, as well as *funding of legacy systems* to shape the near-term objectives (Department of Defense, *Military Transformation—A Strategic Approach*, 2003).

The goal of risk management in science and technology is to seek workable solutions by exploiting technology advantages, while continuing to incorporate innovation into military organizations (Sinnreich, July 14, 2002). Technology alone does not dispel uncertainty or eliminate frictions that occur from actions within our current organizational structures. War and transformational change are inseparable, and success in both is about identifying and mitigating the major risks in a cost-affordable manner.

TRANSFORMATION

War transforms an Army. America is at war, while simultaneously revamping policies and processes to change and reshape the Department of Defense workplace. Most large organizations—like Dell’s Just-in-Time Operations—embrace continuous adaptations to remain ahead or overtake their competitors. Being at war accelerates change from the academic debates and speculations into an immediate need for realistic approaches to develop and deliver new capabilities, which are needed now.

The Army has an extraordinary record of anticipating and leading change. The 1960s brought about the advancement of the airmobile concept; the 1970s emphasized doctrine development and training revolution; and the 1990s introduced digital technology warfare (Fastabend & Simpson, February 2004). These remarkable innovations all require the willingness to use resources differently to maximize the use of new capabilities.

Transformation of all types focuses on effects-based thinking. The strategic objective of this thinking is to obtain a desired outcome through the collective application of the ideas obtained at the tactical, operational, and strategic levels. This approach, when applied to the challenge of JFHQ WAN upgrades, should change the structure and the actions ARNG decision makers incorporate and stress in the planning and execution of their network upgrade operations.

AXIOMS

Mr. David J. Ozolek, the Executive Director of the Joint Futures Lab for U.S. Joint Forces Command, J9, recognizes that there are many definitions for transformation. This official knows the Army’s Transformation Strategy has three major components: the Process, Capabilities, and Culture. Ozolek’s view is slightly different from the ideas above, but it supplements this discussion. It suggests the following (Ozolek, June 24, 2005):

- Do things in a fundamentally different (and better) way
- Enable by technology
- Accomplish upgrades with minimum change

The lessons learned in 4 years of the GWOT remain the catalysts for comprehensive change within the JFHQ WAN community. The ARNG should use PFM to further examine its network baselines and assess concepts that employ new organizational constructs, capabilities, and policies to achieve long-term, enterprise-

level improvements. It should then determine whether these findings are sufficiently transformational to justify major investments. Finally, ARNG decision makers should adjust JFHQ WAN *governance and funding* to well-engineered, validated IT initiatives that ultimately benefit the total ARNG enterprise network.

BENEFITS

While there are many potentially useful technology upgrade options, decision makers sometimes do not fully understand the core factors associated with IT system modernizations or how and where to make the best use of new technology. Upgrade solutions should drive the processes. Under no circumstance should resident processes be allowed to constrain possible solutions. Fast, cheap, and reliable equipment is crucial on the battlefield; likewise, the pace of innovation must also increase to align itself with today's rapidly changing technologies. The best new solutions result from a continuous, evolutionary cycle of collaboration, feedback, and experimentation as outlined within PfM. As each participant gains a feeling of responsibility, innovation accelerates in a fundamentally different (and better) way to achieve organization objectives (Department of Defense, 2004 *Army Transformation Roadmap*).

Intel's model of transformational change requires the co-evolution of tactics, technology, and organization (Macgregor, 2003). Co-evolution is the best way to exploit available and emerging technology. The Army should adopt a similar approach to improve its technological transition and insertion approach and not wait for the next new-generation technology platforms. This infusion of intellectual property and the pace of technological advance will combine to slow the implementation process. Information Age military components' forces should do their best to avoid creating platform-constrained systems and do more to become network-centric. In addition, a much larger enterprise network is required to handle new technology and Web-based applications. The Army, as well as the ARNG, is now undergoing the most wide-ranging transformation since World War II, especially in IT.

Transformation is also necessary to ensure U.S. forces continue to operate from a position of overwhelming military advantage in support of strategic objectives. The PfM provides this continuous cycle of innovation, experimentation, and change that leads to a more responsive force, equipment superiority, and supports diverse mission requirements.

INFORMATION TECHNOLOGY MODERNIZATION MODEL

Information management strategic decision makers benefit from models and illustrations of how IT core factors and risks relate to each other. The Lykke's Stool Model (Figure 5) is commonly used in developing strategy. Strategists tend to ask three key questions: Ends, Ways, and Means. The model depicted in Figure 1 represents them as dual-arrow axes. The struggle of conflicting ideas is depicted here as "imbalance." The model's WAYS or MEANS axis tilts towards one of the listed risks. Given the rapid pace of change in today's technology, more should be done to get IT decision makers to pay greater attention to operational shifts in *services* that are necessary to achieve IT strategy objectives. This model also shows that IT operational core factors need to align with actions focused on the achievement of IT strategic objectives.

ENDS

A strategist's first key question seeks to find out "what" needs to be accomplished. Information Management's strength is derived from a balance of *service and support*. New Technology can enable *services* to do things better. However, these new *services* must be harmonized with the other core factors, like PFM, Program Objective Memorandum (POM) *funding*, maintenance of *legacy systems*, and regulatory *governance*.

Leadership balances *service* goals, such as knowledge management, within limits, to complement the force management and institutional risks. Workforce skills must continue to develop and keep pace with technology change. However, the risks associated with training expenses must not be allowed to exceed related technology upgrade costs and life-cycle benefits.



FIGURE 5. LYKKE'S STOOL STRATEGY MODEL

* The ideas represented in Figure 5 are based on publicly available sources of risk to link them with IT core factors in the development of the authors' strategic model.

WAYS

A strategist's second key question concerns how to identify the best courses of action to implement and resource strategic IT objectives. Organizations use analysis and environmental knowledge to determine how to achieve these concepts. IM effectiveness results from *services* enabled by *new technology*, and it can also be achieved when the technology facilitates transition of *legacy systems*, as referenced in Metcalfe's Law. IT investments, concentrated on a few high-priority *service* areas, are the best means to achieve JFHQ-modernized WAN strategic objectives.

Moore's and Metcalfe's laws continue to apply in the development of complex enterprise networks, so it's essential to manage these risks from multiple sources. *New technology* addresses the risk of future challenges, but it can be costly to implement and difficult to replace *legacy systems*. *Legacy systems* have the operational risk of rising costs, vendor's decreasing support, and limited new *Services*. Management should evaluate the best way to deal with *new technology*

and *legacy systems* by considering second- and third-order effects, such as funding availability and return on investment. This approach maintains equilibrium of the risks from the future challenges by leveraging these with existing operational risks.

MEANS

A strategist's third key question asks what specific resources are necessary to apply the best approach to accomplish the objectives. *Governance* and *funding* resources can either support or constrain IT strategic objectives. The benefits are attained from accurately aligning an organization's IT needs to its service needs, thereby successfully carrying out its mission. The goal is to balance the overall risks with a position located at a slightly forward tilt of new *services* to hedge the rapid pace of technology change.

Subordinates use processes and procedures to balance funded resources with relevant *governance*. In the past several years, the economic benefit of IT automation has changed rapidly. Recently, AR-25-1 was modified from a 5-year to 3-year refresh cycle. This updated regulation acknowledges IT's fast pace to obsolescence with its associated loss of vendor support, information assurance shortfalls, and deficiencies due to change, which need more timely, cost-effective alternative product and technology solutions (Department of the Army, *Army Knowledge Management and Information Technology*, July 15, 2005).

CONCLUSIONS

The GWOT is a rapidly changing asynchronous conflict that involves many varied missions and overlapping commands. Rapid successful modernization of ARNG 54 JFHQ WANs enables the Guard to effectively and efficiently participate in and contribute to the GWOT. In addition, completion adds a vital component to the military's transformation. However, these WAN upgrades need to include modern Communications-based services to handle the constantly growing demands for more rapid Command and Control functions; better administrative, health, and welfare support; as well as improved DoD and federal interagency coordination.

The second- and third-order effects of other ARNG decisions yielded marginal results, often not focused on the ARNG's main strategic IT objective, that is, GuardNET backbone and JFHQ WAN connectivity to the GIG. The decentralization of WAN equipment selections via an IM Committee contributed to this situation. Many well-intended IT procurement initiatives did not adequately consider the rapid rate of change in technology or the engineering laws discussed in this article. Committee-based WAN equipment refreshment remains primarily driven by available *Funding*. As a result, only a few JFHQ WANs selected *new technology* upgrades. The latter now maintain a status quo WAN configuration and continue use of earlier technology. The following examples highlighted some of the complexities associated with the WAN upgrade procurement:

ARNG ROUTER FY 2004 STATUS

In 2004, Figure 6 shows 80% of the ARNG Routers were End of Sale (EOS), where vendors provided only software support and available replacement parts but no new hardware products, upgrades, or services. Additionally, 13% of these routers were End of Life (EOL) with no product support, not even for Information Assurance Vulnerability Alert (IAVA) patches.

Since their actions were not visualized within a strategic methodology, several equipment refresh efforts have not matched pace with Moore's Law. RCAS Phase III procured this equipment over 8 years ago. Then, processor performance was 1,000 MIPS (Pentium II). Today, they're beyond 10,000 MIPS (Xeon). The refresh of the ARNG Switches was slightly better to yield a 60% EOS for these key network components. Both examples show that these core factors, i.e. *Funding*, were not properly aligned with the Guard's IT strategic objectives.

ARNG FY 2005 ROUTER SELECTION

Also in 2004, the ARNG Network consisted of more than 3,000 routers of 70 different types/models. The 2004 procurement IT catalog for the ARNG listed 16 different routers and 30 switch models. This represented a refresh strategy that offered lower capacity choices to reduce unit cost for greater procurement quantities. This yielded a funding-based approach, rather than one focused on new capacity and improved network services.

When you compare the list of available routers (Figure 7) to identified service needs, and then apply the associated engineering laws, the choice selection becomes limited. First, consider router performance in a mixed-traffic environment. Metcalfe's Law indicates the network growth value will increase with service expansions from data, voice, and video users. Then, when Nielsen's Law is overlaid against potential router performance, it reveals a situation that quickly discourages the use of lower-

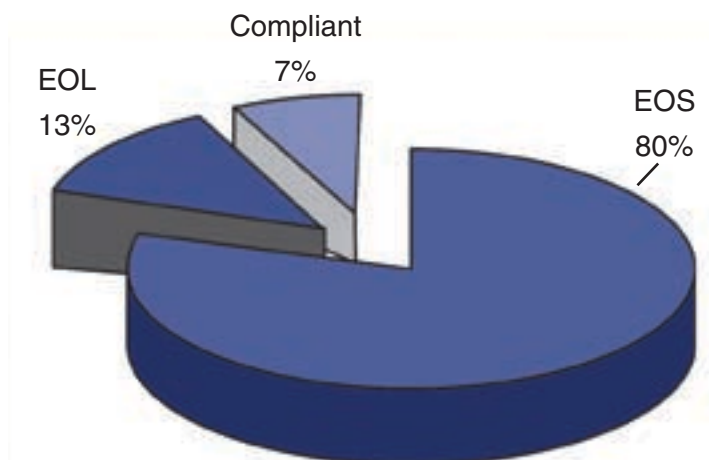


FIGURE 6. ARNG ROUTER FY 2004 STATUS

capacity routers. Finally, services for firewall and Intrusion Detection System (IDS) protection require additional bandwidth performance and router capacity. Therefore, router selection is limited to a few choices, and there are still router procurement quantity and deployment decisions to be made by the ARNG.

Applying the network's Pareto Analysis also shifts the focus of ARNG hardware refresh to the network half that affects 81% of the user community service needs. Portfolio Management, when teamed with Moore's Law, indicates the reuse of existing equipment will satisfy the service needs for the remaining 19%. More performance is certainly desired, but the limits imposed by Moore's and Nielsen's Laws restrict cost-efficient refresh to 81% of the customer base. This fact should shift equipment selection away from a capability-based deployment towards a more beneficial effects-based solution.

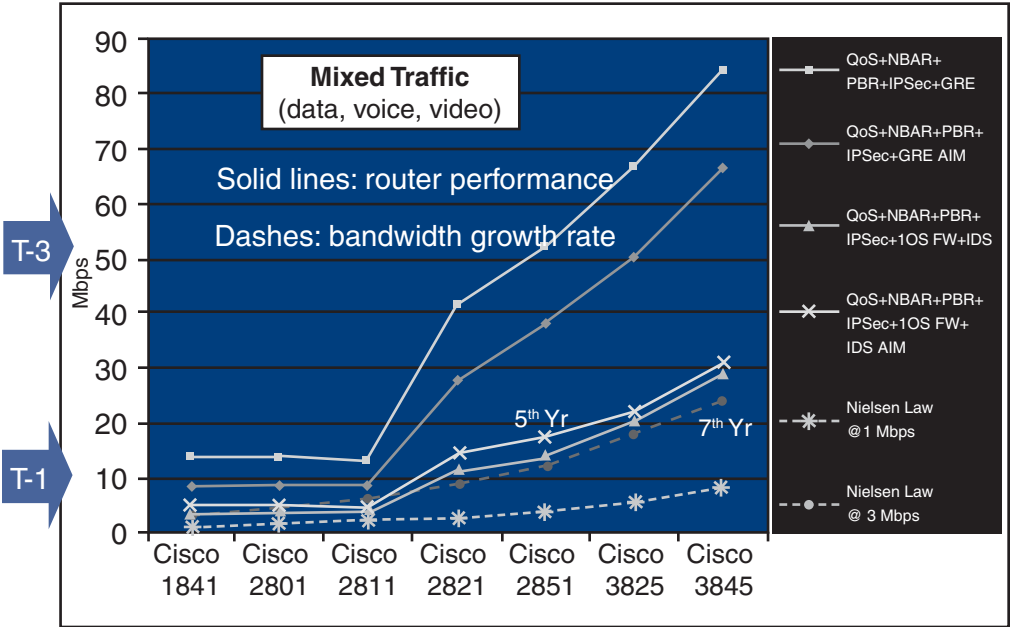


FIGURE 7. ARNG ROUTER FY 2005 SELECTION

Transformation focus should be an effects-based solution. The Army has a record of leading such initiatives. These normally require a willingness to use existing resources differently. Leaders who model Information Technology core factors and visualize their second- and third-order effects can exploit technology rules-of-thumb or “laws” to create effect-based solutions that coincide with an efficient military transformation.

RECOMMENDATIONS

The Portfolio Management process provides a centralized guidance and oversight that enables stakeholder participation, collaborative decision making, and decentralized execution of the WAN modernization for the ARNG 54 JFHQ. The IT organization should use PfM for implementing an effects-based approach that aligns business needs. The key is in the execution.

A strong portfolio management program should:

- Maximize IT investment value while minimizing risk.
- Improve communication and alignment between IT and the strategic plan.
- Encourage “team” leaders versus department or mission area.
- Support an enterprise approach to IT investments and management.

The Information Technology Modernization Model represents limited resources among core factors within a strategic structure to visualize an alignment of IT strategic objectives. Future efforts need to link these IT core factors and apply the “drivers” or engineering laws of technology pace of change. These laws also indicate that attempts to retain existing *legacy systems* or isolated *new technology* solutions will fail IT long-term objectives. Finally, decision makers at the operational level, who deal with these core factors, can exploit technology changes to achieve the strategic IT objectives of their organizations.



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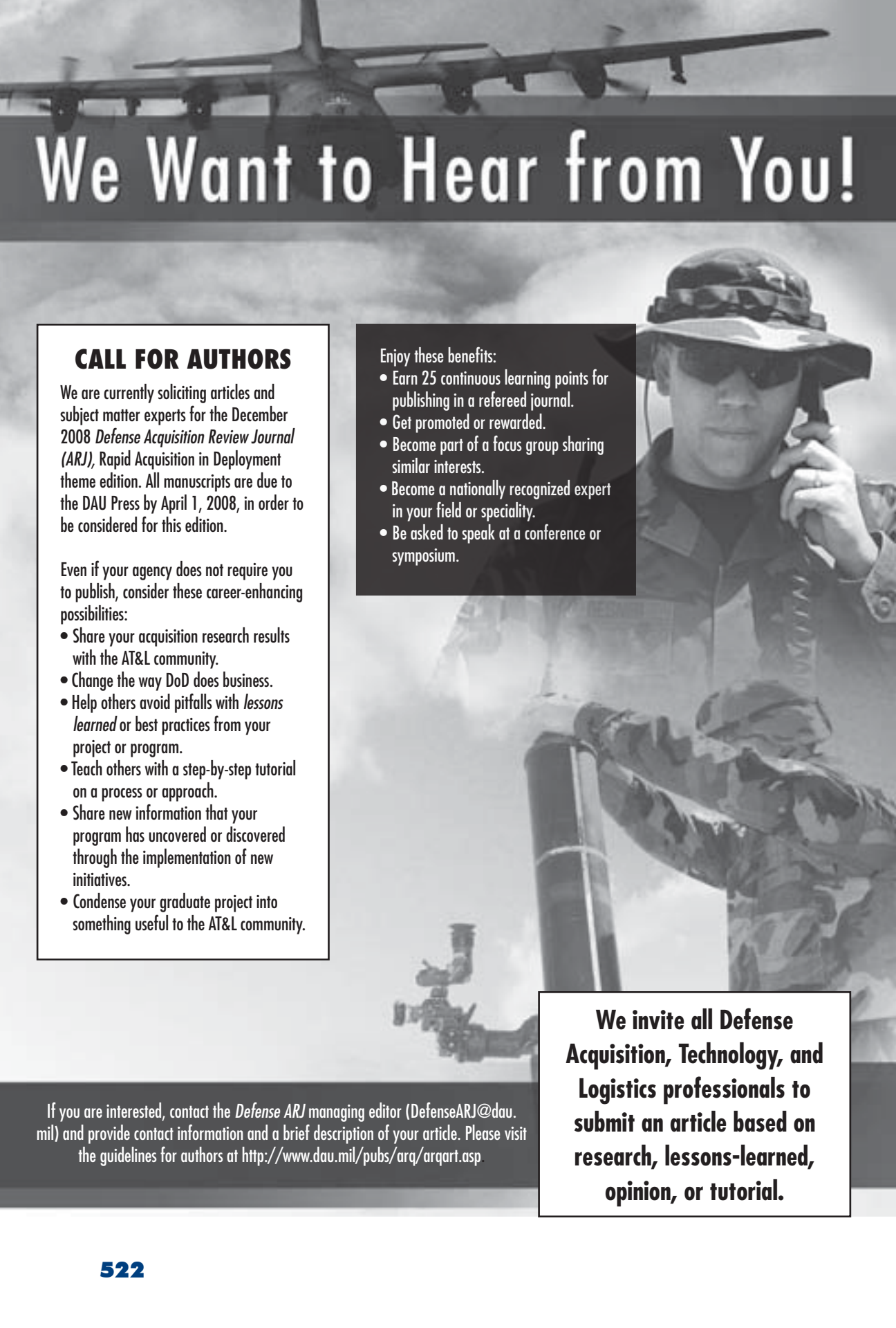
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