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47

DAUAA Research Paper Competition: 1st Place
The Future of Integrated Supply Chain Management
Utilizing Performance Based Logistics
LCDR Wes Griffin, USN

DAUAA Research Paper Competition: 2nd Place
Joint Attack Munition Systems (JAMS) Project Office
Improving Support to the Warfighter
Barry Beavers
William Ruta

DAUAA Research Paper Competition: 3rd Place
Employing Organizational Modeling & Simulation
of the KC-135 Depot's Flight Controls
Maj Matthew A. Paskin, USAF
Maj Alice W. Treviño, USAF
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Stryker Suitability Challenges in a
Complex Threat Environment
Paul Alfieri
Don McKeon

Independent Program Oversight
An Answer for Major Weapons' Success?
Emory Miller

The Lifecycle of Innovations
Jerome H. Collins
Joseph W. Moschler



DEFENSE LIFE CYCLE MANAGEMENT:
SUSTAINING DoD WEAPON SYSTEMS

SPECIAL EDITION
DAUAA RESEARCH PAPER
COMPETITION

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DEFENSE ACQUISITION REVIEW JOURNAL



A NOTE FROM THE EXECUTIVE EDITOR

3

THE FUTURE OF INTEGRATED SUPPLY CHAIN MANAGEMENT UTILIZING PERFORMANCE BASED LOGISTICS

LCDR Wes Griffin, USN

Current logistics concepts yield predictive, linear supply chains that operate in traditional, hierarchical command and control structures. Current efforts to modernize logistics focus on increasing system efficiency, reducing mobility footprint, implementing Performance Based Logistics (PBL) strategies, and creating a transactional data-sharing environment. Logistics support in a transformed military will require prioritized support at the point of effect, with a streamlined end-to-end process back to the source of supply to satisfy the full range of military operations. Sense and Respond Logistics and PBL strategies hold great promise to reengineer our supply chain process and provide improved, cost-effective support to the warfighter.

19

JOINT ATTACK MUNITION SYSTEMS (JAMS) PROJECT OFFICE IMPROVING SUPPORT TO THE WARFIGHTER

Barry Beavers and William Ruta

The Joint Attack Munition Systems (JAMS) Project Office improved support to the warfighter with its implementation of the Life Cycle Management Command (LCMC) concept. LCMC was defined by the Program Executive Office for Missiles and Space as the vision to get products to the soldier faster, make good products even better, minimize life-cycle cost, and enhance the synergy and effectiveness of the Army Acquisition, Logistics and

Technology (ALT) communities. This article will discuss both organizational structure changes and process changes within the JAMS Project Office to implement LCMC and how these changes improved support to the warfighter.

27

EMPLOYING ORGANIZATIONAL MODELING AND SIMULATION OF THE KC-135 DEPOT'S FLIGHT CONTROLS REPAIR CELL

Maj Matthew A. Paskin, USAF, Maj Alice W. Treviño, USAF, Geraldo Ferrer, and Col John T. Dillard, USA (Ret.)

Today's environment of increased operations tempo is stressing the KC-135 Stratotanker fleet. With an 80-year life span expectancy, effectively maintaining these aircraft is challenging. This research modeled the KC-135 programmed depot maintenance (PDM) flight controls repair cell to identify improvement opportunities within the repair process. Computational organizational modeling (COM) incorporates the human element along with organizational design theory. By employing COM to analyze the flight control repair cells, the authors examined design modifications applied to the baseline model and analyzed output variables, such as cycle time and project integration risk. The study concluded with presenting organizational design alternatives for decision makers to enhance the flight controls repair process.

49

STRYKER SUITABILITY CHALLENGES IN A COMPLEX THREAT ENVIRONMENT

Dr. Paul Alfieri and Dr. Don McKeon

The cost of operating and maintaining weapon systems is a large expense to the Department of Defense, and suitability performance is a major factor affecting these costs. Systems with poor suitability performance (such as low reliability, high failure rates, high spare parts usage, and low availability) are extremely difficult to support in a constrained resource environment. For many DoD acquisition programs, suitability lags effectiveness during program development. Suitability determinants (such as reliability and maintainability) are generally not addressed early enough during program development (prior to fielding) and are not prioritized with the same vigor and discipline as performance parameters like speed, accuracy, and lethality. The JROC, DOT&E, and USD (AT&L) have each called for increased attention to suitability improvement.

65

INDEPENDENT PROGRAM OVERSIGHT: AN ANSWER FOR MAJOR WEAPONS SYSTEMS' SUCCESS?

Emory Miller

The Department of Defense (DoD) has a long and consistent history of major program successes and failures. Unfortunately, because of the nature, size, and complexity of DoD endeavors, when projects fail losses are great to both the warfighter and the taxpayer. The question that begs an answer is: Why do DoD's programs and projects continue to fail considering the department's investment in program management and its long history of lessons learned in acquiring major weapons systems? Research suggests that the answer might lie in the execution of the programs and lack of independence in program oversight.

75

THE LIFE CYCLE OF INNOVATIONS

Jerome H. Collins and Joseph Moschler

Innovations have been shown to have a positive influence on the success of organizations. However, without individual and group creativity, innovations cannot occur. Likewise, the benefits of those innovations will never be fully realized in an organization unless each innovation is adopted and diffused throughout the organization. This article will lead to a better understanding of the relationship between creativity, innovation, and diffusion in the context of the *The Life Cycle of Innovations*. Much can be learned from the research that has been done on the subject of innovation. Throughout this article, the findings of that research will be presented and conclusions drawn for further consideration by senior leaders of the defense acquisition workforce.

85

CALL FOR AUTHORS

87

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DEFENSE ARJ EXECUTIVE EDITOR



Welcome to this very special issue of the *Defense Acquisition Review Journal*. About six months ago, the DAU Alumni Association (DAUAA), along with the DAU Research Department, initiated the annual Hirsch Research Paper Competition for the DoD acquisition community (including all members of the Defense Acquisition Workforce, the DAU faculty, and the entire commercial defense industry). The theme for research papers in the 2008 competition is: ***“Defense Life-Cycle Management – Sustaining DoD Weapons Systems.”*** This theme is consistent with the next annual DAUAA Acquisition Community Symposium, which will be held at Fort Belvoir, VA, on April 15, 2008. To increase interest in this competition, the DAUAA offered prize money for the top papers. Therefore, in addition to the Hirsch Award, the top three papers will win \$1000, \$500, and \$250 respectively. A panel of subject matter experts reviewed all submitted research papers and selected the top three winners. The winners will be officially recognized at the DAUAA Acquisition Community Symposium, and cash prizes will be presented there. This research paper competition results from a special relationship between the DAU Alumni Association, the DAU Research Department, and the *Defense Acquisition Review Journal*. I am extremely pleased and proud to publish the three winning papers for the first annual Hirsch Research Paper Competition in this issue of the Defense ARJ.

The 1st place winning research paper for the 2008 Hirsch Research Paper Competition is “The Future of Integrated Supply Chain Management Utilizing Performance Based Logistics,” by LCDR Wes Griffin, USN. This paper focuses on the potential cost and readiness benefits of utilizing two industry best practices: Sense and Respond Logistics (S&RL), and Performance Based Agreements.

The 2nd place winning research paper is: “Joint Attack Munition Systems (JAMS) Project Office Improving Support to the Warfighter,” by Barry Beavers and William Ruta. This paper examines how the JAMS Project Office improved support to the warfighter with its implementation of the Life Cycle Management Command (LCMC) organizational concept. The authors discuss both organizational structure changes and process changes within the JAMS Project Office to enable implementation of the LCMC organizational concept.

The 3rd place winning research paper is: “Employing Organizational Modeling and Simulation of the KC-135 Depot’s Flight Controls Repair Cell,” by Maj Matthew A. Paskin, USAF; Maj Alice W. Treviño, USAF; Dr. Geraldo Ferrer; and Col John T. Dillard, USA (Ret.). This research effectively employs computational organizational modeling techniques to identify improvement opportunities with the KC-135 Depot Repair process. The authors conclude by presenting organizational design alternatives for decision makers to enhance the flight controls repair process.

The fourth research paper in this issue also covers the same theme of life-cycle management and sustainment of DoD weapons: “Stryker Suitability Challenges in a Complex Threat Environment,” by Dr. Paul Alfieri and Dr. Don McKeon. This research paper addresses how suitability issues influence supportability and operational availability in a dynamic, high-tempo, asymmetric combat environment. The Stryker System is still relatively new and was deployed extremely rapidly to meet an urgent combat need. While the system is performing well, the costs to sustain the required levels of readiness and performance are high, and yet to be fully determined.

The fifth research paper in this issue is “Independent Program Oversight: An Answer for Major Weapons Systems’ Success?” by Emory Miller. This article presents a thoughtful examination of the relationship between program oversight and program success in DoD weapon programs. The author explores the governmental decision-making processes for major acquisitions.

The sixth research paper in this issue is “The Life Cycle of Innovations,” by Jerome Collins and Joseph Moschler. The authors provide insight into the relationship between creativity, innovation, and implementation. Finally, and most importantly, the last step of this process, diffusion of these innovations into organizations, is a leadership challenge that should be addressed at the appropriate level.

With this issue, Defense ARJ says goodbye to two talented visual information specialists: TSgt James D. Smith, USAF, and SPC. Kelly Lowery, USA. Their creativity and artistic expertise have been evidenced throughout many issues of the journal in charts, graphs, and most notably, in many of the article lead photographs. TSgt Smith has also been responsible for a number of the journal covers. The contributions of TSgt Smith and SPC Lowery have been greatly appreciated, and we wish them all good fortune in their future endeavors.

Dr. Paul Alfieri
Executive Editor
Defense ARJ



SPC Kelly Lowery, USA, is a visual information specialist at the Defense Acquisition University. With over 3 years of service with the Army, she has served in the Washington, D.C. area and is preparing for a tour of duty in South Korea. SPC Lowery was recently named DAU's Junior Enlisted Person of the Year. In 2001, she graduated from Louisiana Tech University with a Bachelor's degree in graphic design.



Technical Sergeant James D. Smith, USAF, is a Visual Information Craftsman and the Noncommissioned Officer In Charge of the Visual Arts and Press Department at the Defense Acquisition University. His extensive experience includes the design, development, and production of print-related media and interactive multimedia. TSgt Smith conceived and designed the last 5 covers for the Defense ARJ and the majority of the article lead graphics, frequently also doing the photography. In addition, he provided illustration support for Defense AT&L magazine, DAU's other periodical. During his 12 years of service, TSgt Smith has served in several other career fields, notably intelligence and aircraft maintenance. With the Air Force deletion of his current career field, TSgt Smith will retrain as a Chaplain's Assistant after completing his current assignment.

BIOGRAPHY

**APRIL
2008**



Image designed by Jim Elmore

THE FUTURE OF INTEGRATED SUPPLY CHAIN MANAGEMENT UTILIZING PERFORMANCE BASED LOGISTICS

LCDR WES GRIFFIN, USN

Current logistics concepts yield predictive, linear supply chains that operate in traditional, hierarchical command and control structures. Current efforts to modernize logistics focus on increasing system efficiency, reducing mobility footprint, implementing Performance Based Logistics (PBL) strategies, and creating a transactional data-sharing environment. Logistics support in a transformed military will require prioritized support at the point of effect, with a streamlined end-to-end process back to the source of supply to satisfy the full range of military operations. Sense and Respond Logistics and PBL strategies hold great promise to reengineer our supply chain process and provide improved, cost-effective support to the warfighter.



We must transform ... the DoD ... by encouraging a culture of creativity and intelligent risk-taking.

—Donald Rumsfeld, Secretary of Defense (2002)¹

The high cost to support the Global War on Terrorism (GWOT), most recently referred to as the Long War, has generated a requirement for all federal agencies to review current and future operations, and budget to identify areas of cost savings. The Navy has coined the phrase cost-wise readiness outlining the concept

of support for our military combat operations while minimizing overall costs to the taxpayer. During the 1980s, in the midst of the Cold War, then-President Ronald Reagan increased military spending, building up a military that would be able to project force abroad and protect national interests around the globe, in an attempt to stop the spread of communist ideology. The result is now evident; we outspent the Soviet Union and won the Cold War. Since the termination of the Cold War, however, military spending has decreased dramatically, and the subsequent recapitalization of military weaponry has slowed. With the government's focus now shifting towards military capabilities, and the emergent requirements resulting from the Long War, the period of military drawdown and realignment has exposed our military's vulnerabilities to support protracted as well as prolonged engagements.

This article focuses on integrated supply chain management and the potential cost and readiness benefits of utilizing two industry best business practices: Sense and Respond Logistics (S&RL) and Performance Based Agreements (PBA). The S&RL framework exploits advanced technologies through highly adaptive, self-synchronizing functional processes designed to drive shorter decision cycles and faster responses. The commercial-military support structure has evolved through necessity to cut costs, reducing both research and development spending as well as warehousing and transportation costs, while maintaining the ability to deliver the right material to the warfighter in the right quantities at the right time. Two primary determinations upon which I focus the research and arguments presented in this article are: 1) whether commercial best business practices such as S&RL are applicable to Department of Defense (DoD) logistical support methodology; and 2) whether S&RL and PBAs can satisfy the future requirement for joint, integrated supply chain management and distant support.

BACKGROUND

The security environment and the joint forces' role in it have changed. The future joint force will operate in a complex and uncertain global security environment. The ultimate success of military deployment and mission capabilities is tied to the readiness of the warfighters and the ability to sustain them, getting needed material from the "factory to foxhole" (Catano-Pardo, Lin, & Williams, 2006, p. 6).

The application of new military concepts and advanced technology has led to the development of capabilities that can transform the structure and operations of the military forces and DoD enterprise to succeed in the known security environment and to anticipate and prepare for other, yet unknown threats. This emerging global security environment represents a new set of challenges, sometimes contrary to the rules by which the United States fights its wars. The new threats are broader and include global, regional, and local elements. International organizations, allied nation states, rogue nations, hostile states, and terrorist groups all contend within this environment. Adversaries include state and non-state actors, criminal organizations, and transnational groups, and are often difficult to distinguish from noncombatants. They are multi-dimensional, flexible, distributed, information-aware, and rapidly adaptive to U.S. tactics. Increasingly, these threats have at their disposal readily

available, inexpensive, and efficient methods of creating large-scale effects. Recent examples of basic asymmetric warfare include 9/11 suicide terrorists, employment of improvised explosive devices, and cyber attacks on U.S. computer networks. Military agencies worldwide have found it increasingly difficult to meet these challenges with traditional logistics operations (Castano-Pardo, Lin, & Williams, 2006).

DOD LOGISTICS TRANSFORMATION

DoD leadership has begun to evaluate and understand the changing security environment and now has taken action to steer the direction of future combat supportability through an overhaul and complete transformation of how we do business. In an October 14, 2005, memorandum, then-Assistant Secretary of the Navy for Research, Development and Acquisition John Young² outlined key logistics priorities and initiatives focused on life-cycle management principles, particularly radio frequency identification, Lean Six Sigma, Defense Logistics Agency (DLA) consumable war reserve management, distribution process owner roles and responsibilities, supply chain roadmap, and sustainment. This was the climax to a decade-long push by Congress to streamline acquisition and reduce military budgetary spending. Traditional logistics concepts yield predictive, optimized, linear supply chains that operate in hierarchical command and control structures. Logistics in a transformed military defense structure will require prioritized support at the point of effect, with a streamlined end-to-end process back to the source of supply, for the full range of military operations. Improvements begin with implementing real-time visibility across the entire organization. With a common shared logistical picture, organizations spend less money and time in an attempt to compensate.

Historically, military logistics has taken the approach of satisfying operational needs through mass production, which resulted in iron mountains of equipment, commodities, and spare parts.

Combat operations modernization and evolutionary security threats present a particularly unique challenge to sustainability. Historically, military logistics has taken the approach of satisfying operational needs through mass production, which resulted in *iron mountains* of equipment, commodities, and spare parts. Due to high inventory levels and storage costs, DLA took a look at its own economic retention models. What they found was astounding. In 2006, the Government Accountability Office (GAO) reported that DLA storage of Navy-owned material for which no demand was generated over a 3-year period comprised over 155,000 line items, with an inventory value of \$4.01 billion, and accounted for 1.90 million cubic feet of storage space.

Clearly, a new approach to traditional supply chain management must be investigated.

In 2005, the U.S. Navy ranked 8th in the Fortune 500 annual ranking of America's largest corporations with an annual budget of \$131 billion. Of that, the Navy supply chain spending was \$31 billion, nearly one-fourth of the total budget. Traditionally, we have used historical performance measures to determine effectiveness of the supply system to the needs of the warfighter. The primary measure employed was based on two primary criteria: 1) effectiveness of days, which measured a day's worth of items and compared it to material availability; and 2) historical demand data that adjust the item's normal rate used for resupply calculations.

JUST IN TIME LOGISTICS

As a baseline, DoD logistics agencies receive on average 54,000 requisitions each day, do business with more than 24,000 suppliers, and stock over 5.2 million line items. This conventional methodology may continue to work where demand is predictable and, if time permits, for buildup of stockpiled items. In response, DoD initiated the concept of *just in time* logistics, a product of the 1990s corporate concentration on lowering distribution and storage cost. Just in time logistics was an attempt to apply commercial best practices to lean-out huge inventory requirements, reduce waste post-conflict, and make the transactional logistics system more efficient. Its prime metric is flow rate. Flow rate is the volume of transactions, issues, and receipts measured against a given time period. Just in time logistics works well, but creates a very brittle supply chain and potentially fails due to wartime frictions and changing environments.

ENTERPRISE RESOURCE PLANNING

Current efforts to modernize logistics focus on increasing system efficiency, reducing the mobility footprint, implementing performance-based contracts, and creating a transactional data-sharing environment. In order to respond faster, the logistics professional will depend on Enterprise Resource Planning (ERP) systems, which have been tested and proven to work in the commercial sector. The ERP systems and networks are being applied to DoD logistics in an effort to create a connected environment in which near real-time data can be exchanged and response time shortened. Yet, the latest modernizing approaches have not yielded the kind of adaptive, effects-based logistics system that will support highly modular, dynamic, distributed, and adaptive operations.

SENSE AND RESPOND—A SHIFT IN MINDSET

Advancing technologies and key enterprise functions now allow for a broadening of supply across all potential sources as well as logistics operations in a networked, distributed environment that emphasizes speed of command, quality of effects, and adaptation. Today's logistics must be commander's intent-focused and capabilities-centric to operational tasks, mission, and effects.

Historically, logistics has been the functional capability that determined the success or the failure of a military campaign. Gary Gagliardi's translation of *Sun Tzu's The Art of War* relates the importance of logistics when preparing for war:

Everything depends on your use of military philosophy. Moving the army requires thousands of vehicles. These vehicles must be loaded thousands of times. The army must carry a huge supply of arms. You need ten thousand acres of grain. This results in internal and external shortages. Any army consumes resources like an invader (Gagliardi, 2003).

Clearly, using a large conventional army makes war very expensive and requires a large support system to maintain effectiveness. Long delays in supplying the forces create a dull, drained army and exhaust all available resources. Sense and Respond environments present commanders a prioritized picture of available weapon systems' real-time operational status and historical patterns, allowing them to respond rapidly to momentary strategic strike opportunities.

It is very difficult to change long-standing patterns in the human mind. For the DoD to be effective, we must rethink the way we do business, the context of the future wars we will fight, and the necessary preparation required for sustaining a conflict abroad.

Exactly what is the future of integrated supply chain management utilizing S&RL and PBAs? As previously mentioned, the joint force will operate in a complex and uncertain security environment. New concepts and advanced technology have led to the development of capabilities that have transformed the structure and operations of our forces, as well as supportability factors. Distance support using direct from vendor replenishment and streamlined acquisition procedures will reduce inventory requirements, logistical footprint, and emergent funding requirements for spares and interim parts support. However, to fully implement change, we must be critical of our own procedures. Being effective requires an internal look at the system by which we operate and an intensive probe that transcends the routine. If not, we will continue to do what does not work or what is less effective for years and years. It is time for us to really evaluate how we are doing and shift our mindset (Dukes, 2006).

It is very difficult to change long-standing patterns in the human mind. For the DoD to be effective, we must rethink the way we do business, the context of the future wars we will fight, and the necessary preparation required for sustaining a conflict abroad. From a biblical context, Romans 12:1 states, "we cannot be conformed to this world, but be ye transformed by the renewing of our mind. ..."

(Zondervan, 1994, pp. 1242–1244). DoD leadership, in recent years pursued the most comprehensive transformation of its forces since the early years of World War II, with the goal of improving joint warfighting capabilities to meet current and future full-spectrum requirements. The S&RL is the primary means to provide the framework of focused logistics. It is grounded in network-centric warfare theory and Joint Adaptive Expeditionary Warfare practice. Its concept is based on research from the commercial business industry leader, IBM, and has been modified to fit the managerial framework of the DoD. It maintains some key ideas that are found in both science and business.

The principal tenet of S&RL is the fusion of operations, intelligence, and logistics, resulting in information that is real-time and manageable. The S&RL is the means to provide greater range, depth, and flexibility to the warfighter. When utilizing S&RL and PBAs with the weapon system vendors, the process owner takes on more responsibility for life-cycle support. Through this relationship, military forces can maximize readiness, improve material reliability and effectiveness, and capitalize on network-centric enterprises as all parties collaborate real-time within and across communities of interest. Even a conservative estimate of savings based on improved supply chain procedures can be substantial. For example a 2 percent savings based on the current DoD budget would equate to a net savings of \$150 million in 2005 and \$2.3 billion by 2009.

The next goal of S&RL is to enable logisticians to accurately observe, orient, decide, and act quicker than the supported customer, shortening the decision cycle and steadily moving from reactive to proactive. The S&RL moves logistics to the realm of prediction and preemption, anticipating the warfighter's needs more accurately and more quickly, at the same or reduced cost. Total supply chain integration improves tracking, information exchange, platform autonomies, and employs flexible business rules, which shortens the logistician's decision cycle and better sustains the dynamic battlefield of the 21st century. Through shared situational awareness and better decision support, uncertainty can be reduced and warfighters can make real-time adjustments as they track vehicle fuel levels, meals in stock, bullets fired, and battery life remaining. The S&RL allows for horizontal collaboration and rapid reconfiguration of business rules, process flows, and decision-making models in an extremely dynamic environment.

DoD logistics transformation is comprised of three central concepts: Focused Logistics, Force-centric Logistics Enterprise, and Sense and Respond Logistics Theory.

- ***Focused Logistics*** is recognized as a Joint Requirements Oversight Council (JROC)-approved concept, fully reconciled and incorporated into the focused logistics campaign plan. It is the strategic concept that defines broad joint logistics capabilities that are necessary to deploy, employ, sustain, and re-deploy forces across the full spectrum of combat operations.
- ***Force-centric Logistics Enterprise*** is the vision to accelerate logistics improvements, enhance support to the warfighter, and align logistics processes with the operational demands of the 21st century.
- ***Sense and Respond Logistics Theory*** must be fully implemented by DoD to complete this transformation. It provides the framework that enables faster

combat operations by sensing material needs and responding to those needs before they hinder or slow operations (Office of Force Transformation, 2004).

These concepts are being reconciled into a coherent logistics transformation strategy that will embody a joint focused logistics capability. The DoD must continue to look at ways to incorporate near-term aspects of S&RL into the mindset of Service logistics capabilities and attributes. Ultimately, combat logisticians must provide the warfighter the right personnel, equipment, supplies, and support in the right place, at the right time, and in the right quantities.

Based on today's trend, S&RL principles will mature and evolve into a predictive and preemptive capability. Based on network-centric infrastructure and improved technology, S&RL will enable future battlespace and distributed operations as well as sea basing.

What exactly is the policy shift to S&RL? Sense and Respond Logistics provides timely delivery of improved material readiness and enhanced assets visibility, connectivity, and interoperability. As mentioned earlier, S&RL is grounded in network-centric warfare theory and Joint Adaptive Expeditionary Warfare practice. Bobby Chin, a logistics management specialist and strategic planner for the U.S. Army, describes S&RL in his 2005 white paper.

It [S&RL] is focused on commander's intent, and emphasizes speed and quality of effects across the full range of military operations—prepares the Services for responsive and adaptive logistics operations in a dynamic environment. It enables operations-driven control of theatre logistics, strategic connectivity, and integration of combat operations and support. It helps eliminate stovepipe sub optimization and improve data standardization (Chinn, 2005).

With real-time operations, intelligence, and logistics collaboration, S&RL provides a dynamic picture of the battlefield. A more powerful outcome of this fusion is the use of cognitive agent technologies to mine and present information to the right players across the continuum of operations. Transformed logistics capabilities must support future joint forces that are fully integrated, expeditionary, networked, decentralized, and increasingly lethal. The S&RL measures the effectiveness, and real-time analytics will meet the two primary metrics for speed of response and quality of effects. Based on today's trend, S&RL principles will mature and evolve into a predictive and preemptive capability. Based on network-centric infrastructure and improved technology, S&RL will enable future battlespace and distributed operations as well as sea basing.

Performance Based Logistics (PBL) is a support strategy that places primary emphasis on optimizing weapon system support to meet the needs of the warfighter. Performance requirements are measurable metrics. The PBLs designate a single point of accountability for performance with a Product Support Integrator (PSI) and develop support metrics and accompanying incentives to ensure that the performance objectives are met. In short, PBAs buy performance, not transactional goods and services. The PBL strategies often provide incentives for the process owner to evaluate the entire supply chain, from manufacturing to distribution. The process owner looks at all procedures, removing any non-value-added processes, to obtain outcome-measured goals. Inherent benefits that have been commercially demonstrated are streamlined acquisitions, fewer material defects, delineated outcome performance goals, and process ownership. They facilitate the overall life-cycle management of reliability, supportability, and costs. The PBL strategies integrate acquisition and logistics processes for buying weapon system capability and are based on sound, source of supply decisions and best value analysis. Decisions are based upon business case analyses, which allow process owners to compare product support capability next to prescribed performance objectives and outcomes. The major shift from traditional support to product support minimizes purchasing, contracting, and warehousing costs. Instead of buying pre-determined levels of spares, repairs, and data, the new focus is on buying availability to meet the warfighter's needs, and responding real-time to surges and slumps. The appendix to this article provides a look at a naval maritime weapon system that is currently supported by PBL to illustrate how pre- and post-PBL availability and cost factors actually function.

***When applied in the private sector, supply chains
have demonstrated superior customer responsiveness
at cost savings as high as 50 percent.***

The Defense Department's logistics programs and operations totaled more than \$84 billion in FY 2000, accounting for about one-third of the DoD's budget. This rivals the cumulative operations of the 10 largest corporations worldwide. The high cost to support the GWOT and OPERATION IRAQI FREEDOM has generated a requirement for all federal agencies to review current and future operations and budgets for real areas of cost savings (GAO, 2000). Integrated supply chain management is a proven business strategy that has gained wide acceptance in recent years due to increasing customer demands for quality, delivery, and speed of procurement of materials, transformation of material into finished product, and distribution of that product to end customers. When applied in the private sector, supply chains have demonstrated superior customer responsiveness at cost savings as high as 50 percent. The GAO has noted that efforts to reengineer a logistics system are more successful when various logistics activities are viewed as a series of interconnected processes

rather than as isolated functions. As with any business process, supply chain management can benefit from the principles of reengineering, lean manufacturing, DoD level partnering, and streamlining.

Within the Defense Department, organic depot maintenance infrastructure has 22 public and private sector installations and maintains over \$50 billion in facilities and equipment. Although evolving depot maintenance legislation, policy, and world events could impact all projections, the most current summary-level depot maintenance data available for the period FY 2002–FY 2009 project an increase of 14.6 percent in estimated depot maintenance expenditures from \$20.6 billion to \$23.6 billion in then-year dollars.

In FY 2002, over 68,000 personnel accomplished over 79 million hours of organic depot-level maintenance work on a wide array of repairables. In addition to the organic work, DoD spent over \$8 billion in the private sector for the accomplishment of depot-level maintenance. Over 17 percent of the depot-level workload accomplished is considered intra-Service (GAO, 2000, p. 78).

Depot maintenance is key to the total DoD logistics process that supports millions of equipment items, including 52,000 combat vehicles, 350 ships, and 17,000 aircraft. Depot maintenance is a vast undertaking that requires extensive shop facilities, specialized equipment, and highly skilled technical and engineering personnel to perform major overhauls of weapon systems and equipment, to completely rebuild parts and end items. Depot maintenance facilities also manufacture obsolete material no longer available in the private sector, provide oversight for warranty management, and integrate software and hardware for many of the aging weapon systems.

The PBL strategy has become a potential source of operational advantage and a capabilities multiplier for operational forces. Its capability multiplier effect is derived from its capacity to provide the operational commander an increased range of support options earlier, that are synchronized with the operational effects. The PBL strategy can also anticipate support problems; identify potential constraints early; respond to changes in operational tasks and reprioritization; and address many support issues, including adaptability and speed, effectiveness, flexibility, modularity, and integration. Historically, logistics demand is ultimately unpredictable. Effective support depends on adaptability and speed of response. Logistics networks should self-synchronize through a common environment and set of shared objectives to achieve satisfaction of operational requirements, at the point-of-effect. To that end, PBL strategies focus on achieving the evolving commander's intent and reducing operational risks. They are flexible and highly optimized; resources can be re-directed to support rapidly evolving tasks and effects-based operations. They depend heavily on the established distribution and transportation networks. They also provide modularity and improved visibility into logistics support organized by modules of support capabilities rather than by traditional Service and organizational elements. Lastly, PBL strategies are cohesive, adaptable, and responsive. They build upon sophisticated information technology support that enables data sharing, a common perspective of the battlespace, early awareness of resource consumption and needs, commitment tracking, and support for reconfiguration.

CONCLUSIONS

A performance-based strategy is not a one-size-fits-all approach to alternative product support. The PBL contracts may be executed with organic or commercial providers, at the system, sub-system, or component level, for one or more elements of logistics support, using a range of contractual structures and incentives. In short, PBL strategies provide *properly balanced logistics*—properly balanced between traditional and alternative providers across the spectrum of logistics support requirements. Each PBL strategy is tailored to the specifics of the particular program/system being supported. Most PBL strategies require an up-front investment on the part of industry.

Longer contract terms create strategic, best value relationships, and allow investment costs to be spread over a larger base, contributing significantly to the affordability of PBL arrangements.

Investments can include costs associated with establishment of a commercial infrastructure for delivering and tracking material, additional inventory (both wholesale and piece part), capacity expansion, and warehouse space. The costs associated with these investments vary depending on the scope of the individual program as well as the operational environment of the weapon system. In determining the appropriate contract term, the program manager must consider numerous factors including material lead time, which may be as long as 2–3 years. The timeframe necessary for industry to plan and implement *best value* solutions to managing key program objectives such as material obsolescence and technology insertion must also be considered. Initial investment costs are recouped over the contract term. Longer contract terms create strategic, best value relationships, and allow investment costs to be spread over a larger base, contributing significantly to the affordability of PBL arrangements.

An additional factor is the inherent incentive provided by the pricing structure of PBL arrangements. Pricing on full PBL contracts is typically tied to actual weapon system operating hours through “power-by-the-hour” or operating period pricing (GAO, 2000, p. 101).

Because a contractor is paid the same fixed price regardless of the number of requisitions filled, its incentive is to make in-house investments to improve in-house processes that positively affect the reliability and life cycle costs of the component provided. Many PBL arrangements also include overt performance and benchmark incentives (e.g., parts availability or reliability improvement incentives) to further focus contractor efforts on the requirements of the warfighter.

Many PBLs also improve performance through industry partnerships with organic depots. Organic depots assume the role of subcontractors to industry under PBL, providing touch labor for repair of repair parts. Industry manages the repair process,

provides piece part support, assists with facilitating and promoting defense-industry partnerships, and instills commercial processes. These partnerships have been beneficial for all parties concerned. These organic partnerships also accommodate compliance with core statute provisions (10 U.S.C 2464). To date, no Service component providers have realigned core workload from organic depots to commercial repair under PBL strategies.

In corporate business, the perception prevails that what gets measured gets done. Metrics are essential to evaluating the performance of the contractor in supporting the weapon system and ultimately the warfighter. The need exists to develop sound and realistic performance metrics. Being too aggressive can drive costs up, scare off potential suppliers, and/or make PBLs unaffordable; however, not being aggressive enough can result in inadequate customer support and/or degrade weapon system readiness. The approach is to develop a sound, analytical methodology to determine realistic target goals based on warfighter needs, e.g., a material availability metric must be linked to Operational Availability (Ao). Operational Availability is a performance criterion for repairable systems that accounts for both the reliability and maintainability properties of a component or system. It is defined as a percentage measure of the degree to which machinery and equipment is in an operable and committable state at the point in time when it is needed. The PBL measurements must include operable and committable factors that are contributed to the warfighter's requirement. In short, metrics must be measurable, auditable, and within the scope of the PBL provider's effort.

The PBL strategies hold great promise to reengineer the Defense Department's supply chain process and provide improved, cost-effective support to the warfighter.

Military logistics is mission-critical and can enhance or hinder operation execution. With emerging technologies and techniques, advances in military logistics hold great promise, as DoD logistics organizations become more collaborative and adaptive. Ultimately, military logistics will be able to respond near real time as the environmental conditions change. Sense and Respond logistics offer military leaders the information and decision-making superiority that they need to effectively and efficiently achieve the mission.

The S&RL is focused on commander's intent, and emphasizes speed and quality of effects across the full range of military operations. It prepares the military services and DoD agencies for responsive and adaptive logistics operations in a dynamic environment. It enables operations-driven control of theatre logistics, strategic connectivity, and integration of combat operations and support. It helps eliminate sub optimization and improve data standardization. With real-time operations, intelligence, and logistics collaboration, S&RL provides a dynamic picture of the battlefield. Also, a more powerful outcome of this fusion is the use of cognitive agent technologies to

mine and publish information to the right players across the continuum. Given the nature of modern warfare, it becomes imperative to address logistical and distance support issues with an enormous sense of urgency.

The PBL strategies hold great promise to reengineer the Defense Department’s supply chain process and provide improved, cost-effective support to the warfighter. In short, Sense and Respond Logistics helps to keep the finger on the pulse of the warfighter’s real-time needs. The PBL strategies have proven to lead to better total life cycle support, improved engineering and technical support, and reduced total ownership costs. They place the decision of cost-effective repair/overhaul/replace back in the hands of process owners. This also hedges DoD against increased emergent spending to satisfy obsolescence and diminishing manufacturing/vendor issues that ultimately arise with technology refresh and improvements.



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ENDNOTES

1. Donald Rumsfeld, former secretary of defense, spoke at the National Defense University on January 31, 2002. The full quotation can be found in the following publication: Office of Force Transformation. (2003, Fall). *Military transformation: A strategic approach*. Washington, DC: Office of the Secretary of Defense.
2. John Young is currently the under secretary of defense for acquisition, technology and logistics, a position to which he was nominated by President Bush on June 20, 2007, and confirmed by the Senate on November 16, 2007.

APPENDIX

PERFORMANCE BASED LOGISTICS CASE STUDY

The Naval Inventory Control Point awarded a five-year, fixed price Performance Based Logistics (PBL) contract with Raytheon Missile Systems in Tucson, AZ, for the maritime Phalanx Close in Weapons System (CIWS). This contract, totaling more than \$95 million, is one of the largest and most complex agreements awarded in the inventory control point history, and implemented the first major weapons system to full contractor support. The award (March 2000) culminated 2 years of intense joint negotiations between the government and industry leaders. Raytheon is not only the original equipment manufacturer, but also the repair depot.

Under the PBL contract, Raytheon will assume the full range of requirements determination, inventory management, configuration control, obsolescence management, warehousing, and transportation functions for over 1,000 centrally managed items, a function traditionally assumed by the inventory control point and government repair depots. These items account for more than \$25 million dollars in annual sales and approximately 80 percent of the weapons system total demand. In addition, the incentive-based contract will service not only U.S. naval customers, but all preexisting foreign and allied customers as well.



CLOSE IN WEAPON SYSTEM (CIWS)
PHOTO COURTESY OF U.S. DEPT. OF DEFENSE

CIWS is the Navy's all weather automatically controlled gun system, designed to provide fast-reaction defense capabilities against low-flying aircraft and steep-diving, high-speed, anti-ship missiles. There are currently more than 350 systems installed on more than 190 U.S. Navy ships and another 285 systems installed onboard Foreign Military Sales (FMS) ships. This contract takes the central procurement, management, and supply support roles from the government agency and places them in the hands of the equipment and process owner, Raytheon. The PBL inherent benefits are lower total ownership cost, less infrastructure, and customer service-focused. Other benefits include improved readiness and reliability metrics, long-term commercial/government partnership, and matching rewards to performance.

PRE-PBL STATISTICS

- Material availability (12-month average) 85 percent
- Wholesale inventory valued (in FY 2000 dollars) \$261 million

- Range and depth of repairable and consumable items—950 line items and over 34,000 assets
- Backorders—over 200 unfilled customer orders

POST-PBL STATISTICS

- Material availability (12-month average) 94 percent
- Backorders—less than 5 unfilled customer orders
- Robust FMS support base
- Reduction in Mean Logistics Delay Time (MDLT) by more than 5 days
- Contractor developed and sponsored automated, real-time online requisition tracking system
- Guaranteed response for high-priority requisitions of less than 24 hours
- \$5 million cost avoidance over the life of the contract



Image designed by Jim Elmore

JOINT ATTACK MUNITION SYSTEMS (JAMS) PROJECT OFFICE IMPROVING SUPPORT TO THE WARFIGHTER

BARRY BEAVERS AND WILLIAM RUTA

The Joint Attack Munition Systems (JAMS) Project Office improved support to the warfighter with its implementation of the Life Cycle Management Command (LCMC) concept. LCMC was defined by the Program Executive Office for Missiles and Space as the vision to get products to the soldier faster, make good products even better, minimize life-cycle cost, and enhance the synergy and effectiveness of the Army Acquisition, Logistics and Technology (ALT) communities. This article will discuss both organizational structure changes and process changes within the JAMS Project Office to implement LCMC and how these changes improved support to the warfighter.



The Joint Attack Munition Systems (JAMS) Project Office is subordinate to the Program Executive Office (PEO) for Missiles and Space at Redstone Arsenal. JAMS is responsible for executing the mission (life-cycle manager from cradle to grave) for the following programs: Hellfire/Longbow Missile Program, Hydra 2.75 rockets, Viper Strike, Advanced Precision Kill Weapons Systems, Joint Air to Ground Missile, rotary aviation launchers, and related support equipment.

WHAT IS THE LIFE CYCLE MANAGEMENT COMMAND?

PEO Missiles and Space Operations Order MS-05-02 directed implementation of the Army Materiel Command (AMC) LCMC concept and stated:

Aviation and Missile LCMC Vision is to get products to the soldier faster; make good products even better; minimize life-cycle cost, and enhance the synergy and effectiveness of the Army Acquisition, Logistics and Technology (ALT) communities. It is intended to integrate significant elements of ALT leadership responsibilities and authority to enable a closer relationship between the Army Materiel Command (AMC) Major Subordinate Commands (MSCs) and PEOs. The PEOs will be able to work as an integral part of the AMC MSCs, while continuing to report directly to the Army Acquisition Executive (AAE); likewise, logisticians in AMC will have enhanced input into the acquisition processes to influence future sustainment and readiness. The life-cycle management initiative will provide an integrated, holistic approach to product development and system support (Cannon, 2006, p. 1).

The direction as stated in the operations order was for subordinate project managers (PMs) to transition to an LCMC organization concept. The PMs were to modify business practices in order to gain efficiencies while meeting the PEO mission of *Any Soldier, Anywhere, All the Time!* (Cannon, 2006).

HOW JAMS IMPLEMENTED LCMC

A key construct of the AMC LCMC concept is that the PM mission includes the role of life-cycle manager. Warfighter efficiencies were gained through the implementation of organizational and process changes. All weapon system-unique functions for logistics were moved from Integrated Materiel Management Command (IMMC) to the JAMS Project Manager. The JAMS Logistics Directorate only received 70 percent of the IMMC personnel previously performing these functions. As part of this role, the JAMS Logistics Directorate reorganized to support an LCMC team. The JAMS Program Management Directorate assumed oversight of maintenance/spare parts contracts with no additional manpower. Both of these changes provided the opportunity to execute in a more efficient manner.

JAMS LOGISTICS DIRECTORATE ORGANIZATIONAL CHANGES

Logistics efficiencies were gained by the JAMS Logistics Directorate reorganizing into three divisions. The first division is the Logistics Development Division, which is responsible for developing all the logistics requirements for a new weapon system. These activities are usually conducted early in the life cycle before LCMC becomes involved. In the reorganized Development Division, IMMC personnel were added to this team. The second division is the Logistics Support Division, which is responsible for spare parts item management, maintenance contracting development, and operations and maintenance appropriation (OMA)/Army Working Capital Fund (AWCF) funds oversight. The third division is the Fielding and Readiness Division,

which is responsible for both the fielding and readiness of JAMS products. A JAMS War Room was added to focus resources on the readiness mission.

The JAMS Logistics Director became the rater for both IMMC and PM division chiefs, with the Assistant Program Executive Officer (APEO) for logistics being the senior rater. The Logistics Director is the senior rater for all other directorate personnel. The net effect was that the lines of authority across the system were much clearer. A single JAMS Project Office manager (GS-15) was in the rating chain for all logisticians (IMMC and PM) directly supporting JAMS. This created consistency in expectations and has ensured workload is spread more evenly versus the former lines of authority where only a portion of the workforce was co-located within JAMS.

JAMS LOGISTICS DIRECTORATE PROCESS CHANGES

Additional efficiencies were gained with implementation of process changes. These changes fell into three main areas: procurement of spares, spares availability improvements, and war room establishment.

PROCUREMENT OF SPARES

JAMS spares were procured more efficiently by reducing the administrative lead time. Prior to the LCMC implementation, JAMS spares were purchased outside of the JAMS Project Manager's purview. In many cases, the same supplier was being used for the purchase of the end item and prime item spares. This caused additional acquisition time for both the government and supplier (several different contract actions were being performed when only one was necessary). In addition, the government was missing an opportunity to get the benefits of an economics of scale buy (lower price for the government). Since LCMC implementation, JAMS has added the procurement of most critical spares to the end-item production contracts. This change has eliminated approximately 11 months of administrative lead time, which is an estimated cost avoidance of \$1.1 million (PEO, 2006). In addition to this savings, the government is also getting the price benefit of concurrent pricing with the end item, which equates to additional savings.

SPARES AVAILABILITY

The second area where efficiencies have been observed since LCMC implementation is in the spares availability. Spares availability has continued to improve since LCMC implementation even though the JAMS team only received 70 percent of the personnel. As shown in Figures 1 and 2, overall stock availability averaged 68.7 percent with a standard deviation of 13.6 over the 9-month period prior to LCMC implementation. For the 12-month period after LCMC implementation, the overall stock availability averaged 90.0 percent with a standard deviation of 9.7 (PEO, Missiles and Space, JAMS Program Office, 2006). This is a 20 percent increase in the availability

with only 70 percent of the manpower. This observed increase in availability resulted from a number of different process changes:

- extensive coordination with the acquisition center to expedite procurements;
- collaboration with project office engineers and configuration management personnel to ensure technical data accuracy and decrease time required for technical loop processing;
- coordination with RESET points of contacts to synchronize government-furnished materiel requisitions in accordance with RESET schedules; and
- detailed reviews and analysis of backorders, current and future demands.

FIGURE 1. STOCK AVAILABILITY PRIOR TO LIFE CYCLE MANAGEMENT COMMAND ORGANIZATIONAL CONCEPT

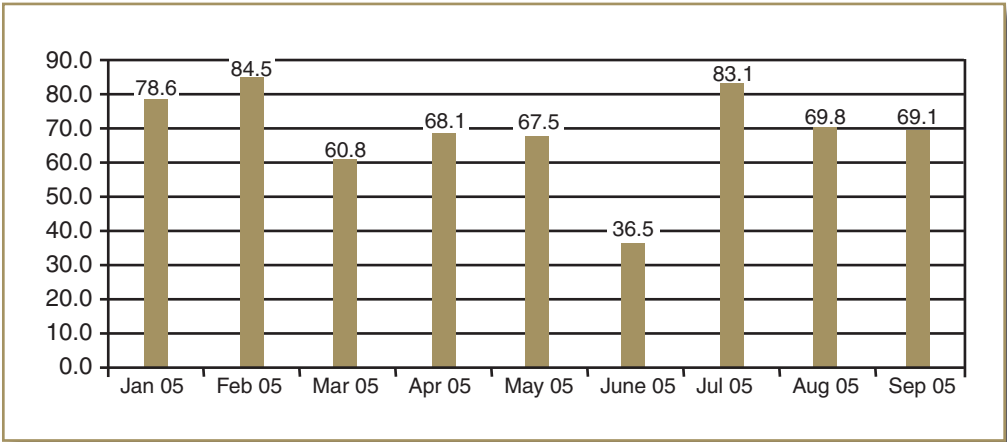
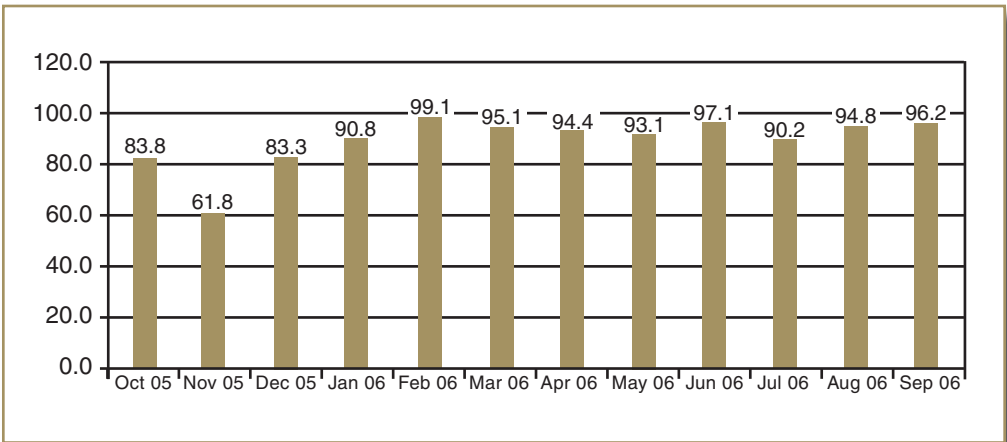


FIGURE 2. STOCK AVAILABILITY AFTER LIFE CYCLE MANAGEMENT COMMAND ORGANIZATIONAL CONCEPT



These process changes were successful because the implementation of the LCMC concept resulted in a more synchronized spares management approach, which positively affected total program support. A by-product of these process changes has led to JAMS personnel (both IMMC and Project Office) increasing their overall systems' knowledge.

WAR ROOM ESTABLISHMENT

The third area where logistics efficiencies have been observed is with the establishment of the JAMS War Room. Reduced cycle times have been achieved in providing responses to the warfighter. Establishment of the JAMS War Room was a process change in the way JAMS supports the warfighter. Since the establishment of the JAMS War Room 18 months ago, it has provided a focal point for warfighters, both in their ability to get help and in our ability to track the health of the systems warfighters are using. The War Room is receiving approximately 50-60 calls or e-mails per month asking for assistance. The JAMS Logistics team mans the war room 24/7—24 hours a day, 7 days a week—with a goal of a call back to the unit within 12 hours to communicate either the answer to the question or the steps being taken to provide an answer to the question. A real benefit to the item managers is that they can access unit readiness data and send critical parts to where they are most needed. Numerous examples can now be cited of how field issues were fixed in days or hours. In one recent example, a unit in Iraq needed armament cables for the OH-58D. The unit was having difficulty finding the right item management organization. The unit called the JAMS War Room, and it was quickly determined that the item was managed by the Tank-Automotive and Armaments Command (TACOM). Within 4 hours, we had worked with management and item managers at TACOM, and assets were in the air on the way to Iraq.

CONCLUSIONS

As documented in the previous paragraphs, much efficiency has been observed since LCMC implementation in the JAMS Project Office. The authors' experiences indicate these efficiencies may be a direct result of LCMC implementation. The authors recommend that additional research be performed to determine the cause and effect relationship of LCMC implementation in the JAMS Project Office or a different PM organization. All these efficiencies translate into additional time and/or dollars that can be used to support the warfighter in other areas.

A secondary result of the organizational and process changes since LCMC implementation is increased communication among the project office team. The IMMC item managers and maintenance engineers are becoming educated on the systems they are supporting. National Stock Numbers are not just numbers, but part of the overall system. Item managers now understand priority and criticality of these parts. The LCMC team (IMMC and PM) is collaborating to look for opportunities to improve the logistics process and solve day-to-day warfighter logistics issues. Giving

project managers (PM) the ability to see from cradle to grave allows the PM the ability to prioritize activities.

Moving from two separate organizations to a combined LCMC organization within the JAMS Project Office has been a success story. It truly means one stop shopping for JAMS products. The warfighter makes one call—24/7—and the JAMS LCMC team will do the rest.



Mr. Barry W. Beavers became Director for Logistics for the Joint Attack Munition Systems (JAMS) Project Office in June 2005. Mr. Beavers manages a staff of approximately 45 individuals engaged in all phases of life-cycle support for all Army Air to Ground Missiles and Rockets.

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Mr. Bill Ruta is a fellow within the Defense Acquisition University Senior Service College Fellowship program focusing on "Leadership." Prior to entering the fellowship program, Mr. Ruta was the Deputy Project Manager for the Joint Attack Munition Systems (JAMS) Project Office. The JAMS Office has overall management responsibility for all Army Air to Ground Missiles and Rockets. He managed approximately \$500 million annually and led a staff of approximately 180 employees.

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EMPLOYING ORGANIZATIONAL MODELING AND SIMULATION OF THE KC-135 DEPOT'S FLIGHT CONTROLS REPAIR CELL

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Today's environment of increased operations tempo is stressing the KC-135 Stratotanker fleet. With an 80-year life span expectancy, effectively maintaining these aircraft is challenging. This research modeled the KC-135 programmed depot maintenance (PDM) flight controls repair cell to identify improvement opportunities within the repair process. Computational organizational modeling (COM) incorporates the human element along with organizational design theory. By employing COM to analyze the flight control repair cells, the authors examined design modifications applied to the baseline model and analyzed output variables, such as cycle time and project integration risk. The study concluded with presenting organizational design alternatives for decision makers to enhance the flight controls repair process.

The Boeing KC-135 Stratotanker's principal mission is air refueling of Department of Defense (DoD) and allied nations' aircraft. As a result of increased operations tempo, refueling and nontraditional taskings continue to stress the aging fleet. Furthermore, "the KC-135 fleet averages more than 46 years and is the oldest combat weapon system in the Air Force inventory" (Solis, Borseth, Coleman, Mardis, Thornton, et al., 2007, p. 1). With an 80-year life span expectancy, maintaining aging aircraft by the most cost-effective and efficient means is a difficult

challenge. This article presents the results of computational organizational modeling (COM) and simulation as an alternative methodology to complement the unit's transformation initiatives by deconstructing the flight controls repair process to identify efficient approaches to oversee process improvement at the repair cells.

The 564th Aircraft Maintenance Squadron (564 AMXS) is a unit assigned to the Oklahoma City Air Logistics Center (OC-ALC) responsible for the U.S. Air Force (USAF) KC-135 aircraft's PDM. Within the squadron, the KC-135 flight controls repair cell (referred to as the Horizontal/Vertical [HV] Repair Cell throughout this article) is charged with refurbishing the aircraft's vertical and two horizontal stabilizers.

The HV Repair Cell faces multiple complexities stemming from mission requirements, financial pressures, workforce reductions, aircraft age, and continuous demands to eradicate waste. The OC-ALC senior leaders and KC-135 PDM management expressed interest in additional approaches to improve PDM operations and invited the Naval Postgraduate School (NPS) to conduct this research. An analysis of the organization is used to assess the HV Repair Cell's leverage of communication across its functions and information sharing between personnel.

Our research utilized POWER 3.0a software developed by the Virtual Design Team (VDT), led by Dr. Raymond E. Levitt and Dr. John C. Kunz at Stanford University. Our objective was to provide decision makers feasible alternatives regarding the KC-135 HV Repair Cell's organizational design. To meet this objective, we developed a computational organizational model of the flight controls repair operation to emulate the current maintenance process. Employing the model helped identify problem areas that might increase repair duration, integration risk, cost, and work backlog affecting decision bottlenecks. After developing the baseline model, we modified it to characterize the implications of subsequent organizational design changes (*what-if* scenarios called *interventions*) on improving the repair process.

METHOD

SCOPE

This research project only considered the organization, personnel, and processes that accomplish flight controls maintenance. The report and modeling effort traced maintenance and administration tasks beginning when the HV Repair Cell receives the vertical and two horizontal stabilizers (after removal from the aircraft) and ending when the repair cell deems the stabilizers serviceable and ready for reinstallation on the aircraft. While the repair cell typically processes up to six sets of stabilizers at once, the model represents the repair of one set of stabilizers, based on information collected from unit personnel. Modeling and simulation of the flight controls repair operation was undertaken using unique POWER 3.0a software. This software was selected because it quantitatively models work processes, information and communication exchanges, human behavior, and organizational design.

LITERATURE REVIEW

In the 1980s, Dr. Levitt formed the VDT to investigate how to predict organizational behaviors using COM. The team based its computational organizational framework on Jay R. Galbraith's (1974; 1977) information-processing concepts. Their research uses COM to examine work processes and information flows associated with project- or task-based organizations (Nissen & Levitt, 2002).

COM enables decision makers to model and simulate prospective organizational design changes, evaluate modifications, calculate impact, and determine if potential benefits are worth the costs and risks. Moreover, it allows decision makers to identify and examine unintended consequences of organizational design changes before implementation.

***Employing the VDT model provides a valuable tool
for managers to design organizations “the same way
engineers design bridges: by building and analyzing
computational models of planned organizations
and the processes that they support.”***

According to Kunz, Christiansen, Cohen, Jin, and Levitt (1998), Galbraith (1977) asserts that organizations possess limited abilities to process *exceptions*. Exceptions occur when local knowledge or authority is insufficient to deal with the information processing requirements, and personnel need advice or direction to accomplish their assigned tasks. The VDT incorporates Galbraith's (1977) view regarding exceptions processing into the computational model. Through functional and project exception probabilities, the model simulates task and project failures and subsequent rework when organizational knowledge or authority is inadequate. The unique benefit of POWer software is that decision makers can preview potential organizational design changes and quantitatively project risk or rework levels prior to implementation, a feature that we use extensively in this study.

Employing the VDT model provides a valuable tool for managers to design organizations “the same way engineers design bridges: by building and analyzing computational models of planned organizations and the processes that they support” (Kunz, et al. 1998, p. 84). The VDT constructed a computational model that emulates real-world situations within the organization (Nissen & Levitt, 2002) and provides a capability to test through simulation and evaluate structural and task modifications. Thus, managers can identify how changes on interdependent activities can affect efforts to avert cost overruns and quality failures (Levitt, 2004). Additionally, managers can identify unanticipated increase in coordination effort or rework occurring from overlapping and interdependent work tasks. According to Levitt and Kunz (2002, p. 4), “this coordination and rework is hidden effort: it is not planned, tracked, managed, or even acknowledged except by the overworked staff.”

Inputs entered in the VDT model transform qualitative attribute values into quantitative values. Depending on a unit’s activities and procedures, these inputs may consume time and generate certain communication requirements and exceptions. Exceptions occur when workers detect task errors requiring additional information or correction (rework). The VDT model assigns all positions a processing speed and the probability of identifying failure, indicating when a sub-activity within an overall activity fails.

The VDT framework is supported by Galbraith’s (1973; 1974) theory that organizations serve as *exception-handling machines* as part of his information processing view of organizations. Based on their conceptualization of Galbraith’s theory, the VDT’s “approach simulates the direct work and the hidden work, i.e., the coordination, supervision, rework, and waiting for all the actors in a project as they perform all of the project tasks” (Levitt & Kunz, 2002, p. 11).

INPUT PARAMETERS TO CONSTRUCT BASELINE

Applying information collected from HV Repair Cell personnel and observation of the flight control repair process, we developed a baseline model using the POWER 3.0a software. The following parameters provided the foundation for the KC-135 HV Repair Cell model: (a) milestones, (b) tasks, (c) positions, and (d) meetings.

Milestones

Milestones identify the objective of the work performed and indicate the beginning or ending of all work to complete the milestone’s objective. We also defined the tasks to accomplish each milestone. The repair process comprises four milestones: acceptance/disassembly, inspection, repair, and buildup (Figure 1).

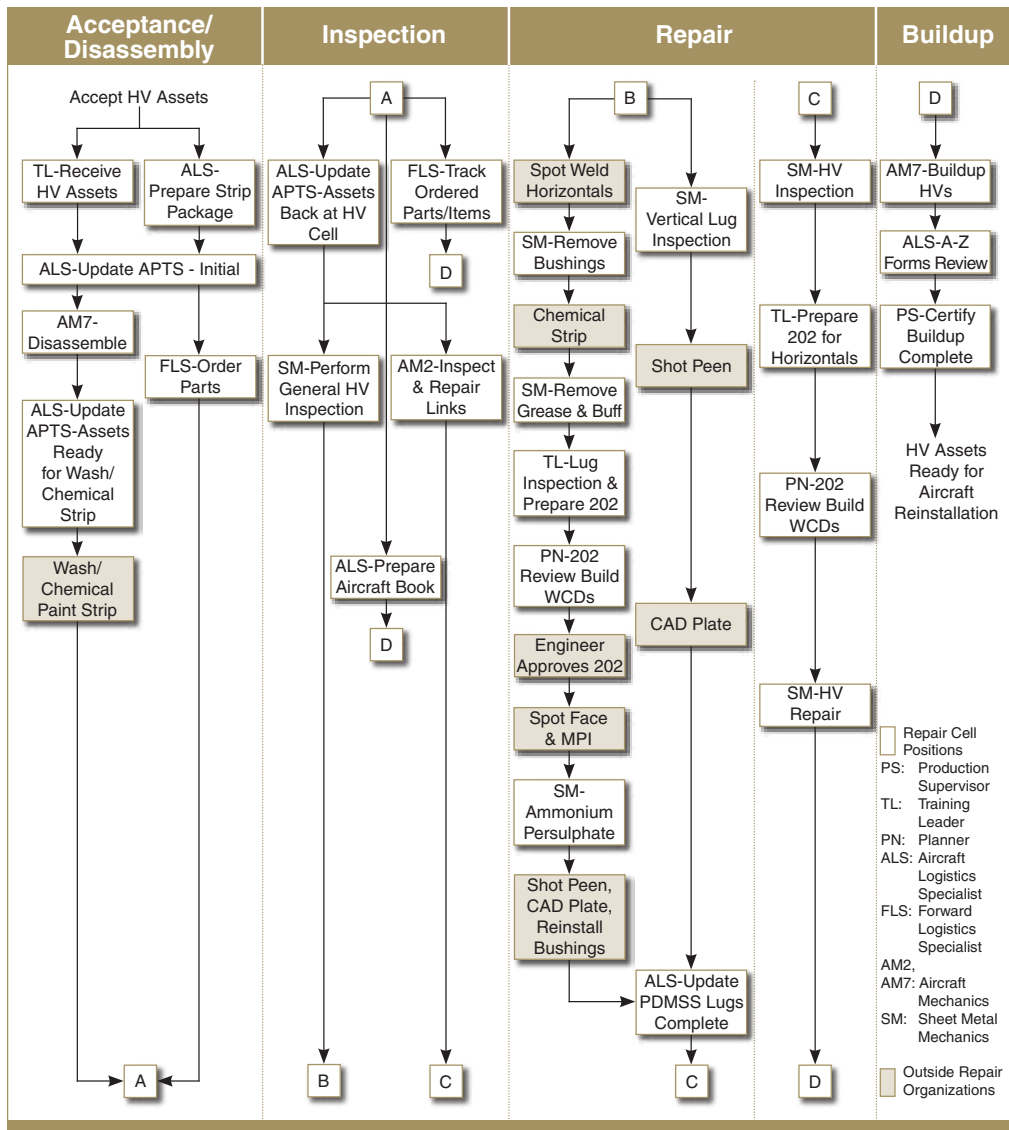
FIGURE 1: HV REPAIR CELL MODEL’S FOUR MILESTONES



Tasks

Tasks represent all the jobs that employees are responsible for completing. During the repair process, simultaneous production, scheduling, planning, and logistics operations occur. The HV Repair Cell model incorporates multiple tasks and sub-tasks taking place throughout the flight controls repair process. Figure 2 illustrates the model's four milestones indicating the tasks and responsible positions.

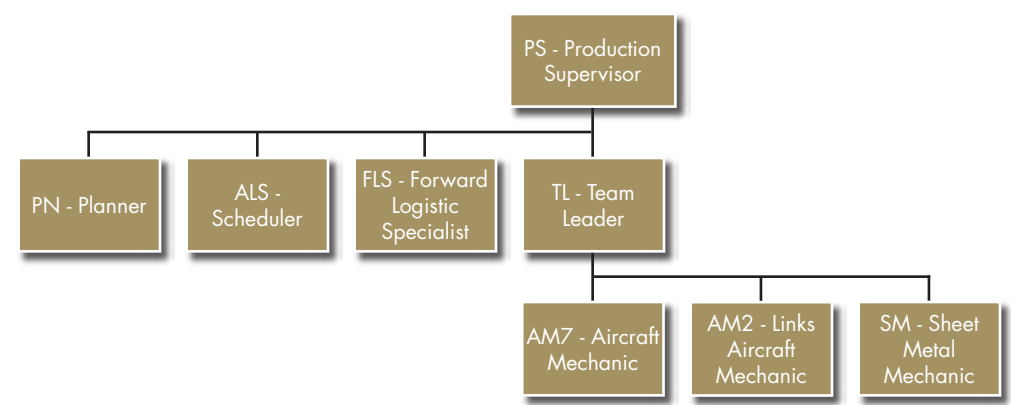
FIGURE 2: HV REPAIR CELL MODEL'S MILESTONES AND TASKS



Positions

Positions account for the personnel responsible for HV Repair Cell tasks. Within the model, eight positions execute repair and administrative tasks and characterize the hierarchy of information flow. Figure 3 depicts our representation of the repair cell positions and how they share information up, down, and across the informational hierarchy. While not a chain-of-command diagram, it shows the positions that execute repairs, accomplish administrative paperwork, and supervise subordinates' efforts (i.e., flight controls repair tasks). The model also includes leadership positions signifying decision-making personnel who regularly receive exception-handling questions on how to resolve errors from subordinates.

FIGURE 3: HV REPAIR CELL MODEL'S POSITIONS AND INFORMATION HIERARCHY



Meetings

Meetings represent important methods and times whereby personnel regularly, formally, and reliably transfer information about repair and administrative tasks and procedures. There are three meetings in the baseline model to coordinate daily asset schedules, conduct roll call, and share end-of-shift turnover information.

ADDITIONAL INPUT PARAMETERS TO CONSTRUCT BASELINE

Once the foundational parameters were established, we analyzed the organization's decision-making policies supporting the flight controls repair operation. These policies and procedures impact micro-decision-making behavior of HV Repair Cell workers and supervisory personnel.

- **Team experience** defines the extent to which organizational members previously and successfully worked together to accomplish the project. The set value determines how quickly or slowly positions process information.
- **Centralization** characterizes whether decisions are made by senior-level positions or decentralized to lower-level (subordinate), responsible positions.

The set value impacts project duration, waiting time, position backlog, and project integration risk.

- **Formalization** defines whether communication within the organization tends to occur formally in meetings, informally between position members, or evenly between formal and informal methods.
- **Matrix strength** describes the “connectedness” of the organization. This setting illustrates the use of informal and formal information exchanges, perceived need to attend meetings, and percentage of formal meetings attended.
- **Communication probability** measures the level of communication required between tasks that are interdependent.
- **Noise probability** measures the probability of interruptions that take time away from position members conducting direct flight controls repair tasks in an ordinary working day.
- **Rework links** represent where rework occurs resulting from and related to identified tasks.
- **Functional exception probability** defines the probability that repair tasks fail due to localized task errors and require rework by the position responsible for the errors. Errors may be detected through self-check procedures, after completion of work by position peers, or supervisor’s review. When the model generates a functional exception, the position responsible for correcting the error either reworks, quickly fixes, or ignores it based on the model’s functional exception probability setting.
- **Project exception probability** defines the probability that repair tasks fail and generate rework for all dependent tasks. If applicable to the organization, these tasks are connected by rework links in the model. The responsible position reworks, quickly fixes, or ignores the error when the model generates a project exception.
- **Communication links** represent task completion and integration dependency. If two tasks require personnel to talk and share information, a communication link is incorporated into the model between those two interdependent tasks. Communication links inform the model these tasks depend on each other for information.
- **Knowledge links** represent relationships and information sharing between coworkers. Coworkers provide information to other employees about task requirements by sharing their skills and experiences. Without knowledge sharing, workers may make decisions concerning task completion that compromise overall task and/or repair quality. By sharing information and communicating within the information hierarchy, employees mitigate the number of functional exceptions and project risk.

Baseline Model

The computational organizational model of the flight controls repair operation emulates the HV Repair Cell's current process and operations. Figure 4 depicts a POWER 3.0a screenshot of the HV Repair Cell baseline model. Within the screenshot, lines correspond to knowledge transfer, information sharing, task interdependencies, and process flow. The three parallelograms at the top of the image represent meetings, the eight *people* objects illustrate positions, the rectangles below the positions represent core *touch* tasks, the hexagons portray completion milestones, and the long rectangles to the upper right represent non-touch tasks.

In the model, positions connect to assigned tasks using task-assignment arrows. Arrows connecting positions to positions from the *head* denote supervisory roles, while arrows connecting positions to positions from the *feet* represent knowledge links. Arrows connecting positions to meetings symbolize required meeting attendance. Sets of arrows between tasks signify interdependencies, rework links, and communication links. Finally, arrows link each task (rectangle) and milestone (hexagon), starting from the HV Repair Start (top left), and ending with the HV Repair Finish (mid right). These show sequential and parallel tasks within the process flow path.

The validity of the baseline model's output was critical to accurately gauge the effects of the applied interventions. Hence, we performed sensitivity analysis to verify the baseline model's validity. The *communication probability* parameter was selected to assess its impact to the HV Repair Cell model. The baseline's duration of 34.32 days provides the closest approximate result—within 1.9 percent of the historical average repair of 35 workdays. We changed the *communication probability* setting from 0.20 to 0.10 or 0.30, which reduced duration by 0.10 percent and 0.19 percent from the baseline's prediction, to 34.29 and 34.26 days respectively. Thus, the baseline model with a 0.20 *communication probability* setting most accurately emulates the actual repair process, showing that the model is robust to reasonable changes in this parameter. The flight controls repair duration predicted by this model sufficiently reflects the observed duration of 35 workdays. The accuracy of the baseline model improves the probability that simulations will predict realistic outputs. Therefore, this model was used to forecast performance outputs, such as expected repair duration, direct and indirect work, waiting time, project cost and risk, and exception-handling.

Interventions

Once the baseline model accurately depicted current flight controls repair operations, we examined eight output parameters from the model's simulation results. The parameters included project duration, direct work time, indirect work time (*measured by rework time, coordination time, exception-handling wait time*), total direct and indirect work time, total project cost, total functional and project exception time (*measured by functional exception work and project exception work*), project risk, and position backlog. After this assessment, we identified seven organizational design interventions to simulate and compare against the baseline model.

PLACEHOLDER PAGE FOR 10" X 12.5" PULLOUT
FIGURE 4: HV REPAIR CELL BASELINE MODEL

BACK OF 10" X 12.5" PULLOUT

- **Intervention 1** added a sheet metal mechanic to the current pool of 14 sheet metal mechanics. This intervention provided insight into how much repair duration could be reduced by increasing this resource.
- **Intervention 2** combined the AM2 and AM7 positions to create one AM9 position with nine aircraft mechanics responsible for all aircraft mechanic tasks. The intervention was projected to show the impact of knowledge-sharing and enhanced training on low-skill-level AM2 personnel. These improvements were expected to reduce project duration and decrease rework time. Because of learning curve effects, the model predicted the need for increased coordination time and exception-handling wait time as AM2 members learned new tasks and asked more questions.
- **Intervention 3** changed the level of *centralization* (decision-making and exception-handling responsibilities) from medium to low, changing the organization's decision-making practices to a decentralized operation. The results of this intervention were expected to decrease overall repair time, rework, coordination, and exception-handling wait time. Yet, low levels of centralization were also predicted to increase project integration risk as lower-level repair cell employees sought less information from higher-level decision makers.
- **Intervention 4** increased the *functional exception probability* parameter value from 5 percent to 10 percent. This intervention evaluated the effects of added stress if the repair process became less standardized and caused more *exceptions*. This intended to mimic the experience with recent KC-135 stabilizers (undergoing PDM) assigned to units in highly corrosive environments that recently displayed more severe corrosion damage. This damage affected repair diagnosis and repair time by causing more exceptions or task errors. Mechanics and administrators made more exception-handling inquiries to the team leader on how to proceed. Thus, to model additional stress on the system, the *functional exception probability* parameter value was raised from 5 percent to 10 percent. Overall project duration, cost, and integration risk were predicted to increase as employees learned new operating procedures. As strain on the flight controls system intensified, the amount of exceptions was expected to escalate.
- **Intervention 5** combined Intervention 2 (create AM9 position) and Intervention 3 (change *centralization* to low). After evaluating the first four interventions' simulation results, we developed a combined intervention to assess potential synergistic effects. This intervention revealed whether beneficial interventions executed in isolation result in the same, incremental, or continued improvement when integrated.
- **Intervention 6** cross-trained and combined all aircraft and sheet metal mechanics to create one *Mechanic Pool* position. Current OC-ALC hiring and operating regulations prohibit employees from formal cross-training. This intervention simulated if the OC-ALC collective bargaining agreement

was renegotiated to allow formal cross-training. The workers assigned to the mechanic pool would require training and certification to complete disassembly, inspection, repair, and buildup tasks. Cross-training was expected to increase learning, knowledge sharing, and skill levels for all mechanics. Additionally, this intervention was anticipated to make accomplishing disassembly, inspection, repair, and buildup more efficient, since only one position (instead of three) would be responsible for these tasks. As one position becomes accountable for all mechanic tasks, repair duration, cost, integration risk, and indirect work time were predicted to decrease. With 23 mechanics working jointly to complete tasks, the amount of exceptions generated by the model was expected to grow, but also be handled more quickly.

- **Intervention 7** changed the following parameters to analyze the expected outcome if three unit personnel retired within the next two fiscal years: *team experience*, *communication probability*, *project exception probability*, and *functional exception probability*. In 2007, the 76th Maintenance Wing offered voluntary retirement incentives (under the federal government's Voluntary Separation Incentive Pay program) to retirement-eligible personnel as part of reshaping efforts to match the workforce with workload requirements (Daniel, 2007). According to the HV Repair Cell's shop supervisor, two sheet metal mechanics and one aircraft mechanic were eligible to retire between September 30, 2007, and September 30, 2009. This intervention simulated and identified the effect on the unit if another retirement incentive program was offered and the three members retired.

Previewing potential organizational changes and subsequent consequences before expending resources offers valuable and cost-effective advantages. Simulating interventions on the baseline model allows quantifying these impacts. Furthermore, the model provides decision makers with quantitative evidence for enacting prospective HV Repair Cell design modifications.

RESULTS

Table 1 shows eight output parameters evaluated during this research:

- a) simulated project duration;
- b) direct work time;
- c) indirect (or hidden) work time measured by rework time, coordination time, exception-handling wait time;
- d) total direct and indirect work time;
- e) total project cost;
- f) total functional and project exception time measured by functional exception work and project exception work;
- g) project risk; and
- h) position backlog.

Table 1: SAMPLE OUTPUT PARAMETERS,
HV REPAIR CELL BASELINE MODEL

Numerical Output	Baseline Model
	Starting Point
Simulated Project Duration (days)	34.32
Direct Work Time (days)	130.52
Indirect (Hidden) Work Time (days):	30.85
<i>Rework Time (days)</i>	5.03
<i>Coordination Time (days)</i>	18.31
<i>Exception-Handling Wait Time (days)</i>	7.51
Total Direct and Indirect (Hidden) Time (days)	161.38
Total Project Cost (\$)	\$60,627.98
Total Functional and Project Exception Time (days)	8.74
<i>Functional Exception Work (days)</i>	7.95
<i>Project Exception Work (days)</i>	0.77
Project Risk	0.07
Position Backlog (days)	2.87
Position with Highest Backlog	AM2 - Links Aircraft Mechanic

SIMULATED PROJECT DURATION

Simulated project duration is the amount of time, on average, the entire HV Repair Cell process takes to complete, including all maintenance and administrative tasks for one set of horizontal and vertical stabilizers.

DIRECT WORK TIME

Direct work time measures the amount of time positions consume as they perform tasks before handling any exceptions generated by the model..

TOTAL INDIRECT OR HIDDEN WORK TIME

Total indirect or hidden work time incorporates rework time, coordination time, and exception-handling wait time.

- **Rework time** is the time all positions need during the flight controls repair process to carry out rework. This time measures the impact if a driver task fails, causing rework time for all dependent tasks linked to the driver task by one of the model's four rework links.

- **Coordination time** is the amount of time positions spend attending meetings and processing information requests from other positions.
- **Exception-handling wait time** measures the time positions consume waiting for a supervisor's response about how to resolve functional or project exceptions generated by the model. If the supervisor is managing other tasks or positions and becomes overly backlogged, personnel may decide to ignore or quickly fix the error and cause project risk to escalate.

TOTAL DIRECT AND INDIRECT WORK TIME

Total direct and indirect work time is the sum of direct work time plus all indirect work time.

TOTAL PROJECT COST

Total project cost is the sum of direct work, rework, coordination, and exception-handling wait costs. These costs were based on POWER's default fixed cost settings for the salary of each position (\$50 per hour) and each task (\$0). Although the true cost of conducting tasks and employing positions was not modeled for this research, the default settings enabled us to monitor relative changes in total project cost for each intervention compared to the baseline model.

TOTAL FUNCTIONAL AND PROJECT EXCEPTION TIME

Total functional and project exception time represents the sum of the time positions take to complete work on exceptions (rework).

- **Functional exception time** signifies the amount of time positions consume repairing specific tasks that fail and require rework.
- **Project exception time** records the time that positions take repairing failed tasks and dependent tasks (attached in the model by rework links).

PROJECT RISK

Project risk represents the probability repaired stabilizer components are not integrated at the end of the repair process because they have defects following rework and exception-handling.

POSITION BACKLOG

Position backlog depicts the number of days of direct and indirect work a position has yet to accomplish. The position with the largest backlog and the corresponding amount is presented.

Tables 3 and 4 summarize the results of the seven interventions applied to the baseline model. Moreover, Table 2 shows a relevance legend to help evaluate the changes in each intervention.

Table 2: Output Value Levels of Relevance

Value (X)	Level of Relevance
$X < 1\%$	No Relevant Difference
$1\% \leq X < 5\%$	Weakly Relevant Difference
$5\% \leq X < 10\%$	Relevant Difference
$X > 10\%$	Highly Relevant Difference

Table 3: Output Parameters, Numerical Comparison to Baseline Model

	Baseline Model	Intervention 1	Intervention 2a	Intervention 2b	Intervention 3	Intervention 4	Intervention 5	Intervention 6	Intervention 7
Numerical Output	Starting Point	Add One SM Mechanic	Create AM9 Aircraft Mech Position (Med Skills)	Create AM9 Aircraft Mech Position (High Skills)	Change Centralization from Med to Low	Functional Exception from 5% to 10%	Combination (AM9 Position & Low Centralization)	Cross-train/1 Mechanic Resource Pool	Retirement
Simulated Project Duration (days)	34.32	33.90	34.21	33.46	34.15	34.98	33.51	29.42	35.03
Direct Work Time (days)	130.52	130.52	127.90	127.90	130.52	130.52	127.90	125.27	130.52
Indirect (Hidden) Work Time (days):	30.85	31.43	33.24	31.22	29.83	43.36	30.03	26.74	47.29
Rework Time (days)	5.03	5.14	4.93	4.96	4.92	10.06	4.75	3.64	10.27
Coordination Time (days)	18.31	18.72	18.82	18.65	18.15	19.41	18.70	17.42	22.06
Exception-Handling Wait Time (days)	7.51	7.57	9.50	7.61	6.76	13.89	6.58	5.68	14.95
Total Direct and Indirect (Hidden) Time (days)	161.38	161.95	161.14	159.12	160.35	173.88	157.93	152.01	177.81
Total Project Cost (\$)	\$60,627.98	\$60,841.87	\$64,767.71	\$56,739.93	\$60,224.56	\$65,543.84	\$56,280.97	\$60,453.35	\$67,813.97
Total Functional and Project Exception Time (days)	8.74	8.71	9.27	8.86	8.64	16.61	8.43	9.31	17.51
Functional Exception Work (days)	7.95	7.82	8.34	7.81	7.82	15.71	7.47	8.19	15.99
Project Exception Work (days)	0.77	0.88	0.92	1.04	0.81	0.89	0.95	1.11	1.51
Project Risk	0.07	0.08	0.09	0.10	0.08	0.08	0.09	0.06	0.12
Position Backlog (days)	2.87	2.85	1.69	1.55	2.87	2.98	1.51	1.43	2.97
Position with Highest Backlog	AM2-Links Aircraft Mechanic	AM2-Links Aircraft Mechanic	TL-Team Leader	TL-Team Leader	AM2-Links Aircraft Mechanic	AM1-Links Aircraft Mechanic	TL-Team Leader	TL-Team Leader	AM2-Links Aircraft Mechanic

Table 4: OUTPUT PARAMETERS,
PERCENTAGE CHANGE FROM BASELINE MODEL

Percentage Change from Baseline (%)	Baseline Model	Intervention 1	Intervention 2a	Intervention 2b	Intervention 3	Intervention 4	Intervention 5	Intervention 6	Intervention 7
	Starting Point	Add One SM Mechanic	Create AM9 Aircraft Mech Position (Med Skills)	Create AM9 Aircraft Mech Position (High Skills)	Change Centralization from Med to Low	Functional Exception from 5% to 10%	Combination (AM9 Position & Low Centralization)	Cross-train/1 Mechanic Resource Pool	Retirement
Simulated Project Duration	34.32	-1.22%	-0.34%	-2.52%	-0.49%	1.92%	-2.37%	-14.28%	2.06%
Direct Work Time	130.52	NO CHANGE	-2.01%	-2.01%	NO CHANGE	NO CHANGE	-2.01%	-4.02%	NO CHANGE
Indirect (Hidden) Work Time:	30.85	1.87%	7.75%	1.19%	-3.33%	40.53%	-2.66%	-13.34%	53.27%
Rework Time	5.03	2.24%	-2.03%	-1.49%	-2.24%	99.99%	-5.51%	-27.67%	104.22%
Coordination Time	18.31	2.23%	2.80%	1.88%	-0.85%	6.01%	2.12%	-4.85%	20.50%
Exception-Handling Wait Time	7.51	0.75%	26.36%	1.29%	-10.09%	84.81%	-12.40%	-24.43%	99.01%
Total Direct and Indirect (Hidden) Time	161.38	0.36%	-0.15%	-1.40%	-0.64%	7.75%	-2.14%	-5.80%	10.18%
Total Project Cost	\$60,627.98	0.35%	6.83%	-6.41%	-0.67%	8.11%	-7.17%	-0.29%	11.85%
Total Functional and Project Exception Time:	8.74	-0.30%	6.14%	1.44%	-1.15%	90.15%	-3.48%	6.60%	100.47%
Functional Exception Work	7.95	-1.61%	4.94%	-1.76%	-1.64%	97.57%	-6.07%	3.03%	101.08%
Project Exception Work	0.77	13.14%	18.25%	33.81%	3.93%	14.93%	22.78%	43.27%	94.27%
Project Risk	0.07	16.48%	32.11%	40.43%	20.51%	17.52%	36.49%	-18.68%	81.10%
Position Backlog	2.87	-0.64%	-41.26%	-45.99%	NO CHANGE	3.66%	-47.56%	-50.18%	3.55%
Position with Highest Backlog	AM2-Links Aircraft Mechanic	NO CHANGE	TL-Team Leader	TL-Team Leader	NO CHANGE	NO CHANGE	TL-Team Leader	TL-Team Leader	NO CHANGE

DISCUSSION

RECOMMENDATIONS

The simulation results of the seven interventions performed in this research provide OC-ALC leaders an analysis of quantitative and qualitative information. Table 5 summarizes the output parameters of the baseline model next to the best, second-best, and third-best intervention models.

Table 5: OUTPUT PARAMETERS OF BASELINE

Output Parameter	Baseline Model Output	Best Model and Output	2nd Best Model and Output	3rd Best Model and Output
Simulated Project Duration (days)	34.32	Intervention 6 29.42	Intervention 2b 33.46	Intervention 5 33.51
Direct Work Time (days)	130.52	Intervention 6 125.27	Interventions 2a, 2b, 5 127.90	Baseline Interventions 1, 3, 4, 7 130.52
Indirect (Hidden) Work Time (days):	30.85	Intervention 6 26.74	Intervention 3 29.83	Intervention 5 30.03
<i>Rework Time (days)</i>	5.03	Intervention 6 3.64	Intervention 5 4.75	Intervention 3 4.92
<i>Coordination Time (days)</i>	18.31	Intervention 6 17.42	Intervention 3 18.15	Baseline 18.31
<i>Exception-Handling Wait Time (days)</i>	7.51	Intervention 6 5.68	Intervention 5 6.58	Intervention 3 6.76
Total Direct & Indirect (Hidden) Time (days)	161.38	Intervention 6 152.01	Intervention 5 157.93	Intervention 2b 159.12
Total Project Cost (\$)	\$60,627.98	Intervention 5 \$56,280.97	Intervention 2b \$56,739.93	Intervention 3 \$60,224.56
Total Functional & Project Exception Time (days)	8.74	Intervention 5 8.43	Intervention 3 8.64	Intervention 1 8.71
<i>Functional Exception Work (days)</i>	7.95	Intervention 5 7.47	Intervention 2b 7.81	Intervention 1, 3 7.82
<i>Project Exception Work (days)</i>	0.77	Baseline 0.77	Intervention 3 0.81	Intervention 1 0.88
Project Risk	0.07	Intervention 6 0.06	Baseline 0.07	Interventions 1, 3, 4 0.08
Position Backlog (days)	2.87	Intervention 6 1.43	Intervention 5 1.51	Intervention 2b 1.55
Position with Highest Backlog	AM2-Links Air- craft Mechanic	TL-Team Leader	TL-Team Leader	TL-Team Leader

AND TOP RANKED INTERVENTIONS

As a result of this research, the following recommendations were provided to OC-ALC leaders:

- Address current hiring and operating regulations to pursue the allowance of formal cross-training within the HV Repair Cell.
- Continue with voluntary informal cross-training of aircraft and sheet metal mechanics within the HV Repair Cell. Expand the number of cross-training tasks as time and effort permit.
- Train and fully qualify all nine aircraft mechanics in disassembly, repair linkages, and buildup tasks to create one highly skilled aircraft mechanic position.

- Identify clear expectations and develop an *HV Repair Cell Transition Plan* to prepare the organization as multiple employees become retirement-eligible.

The output from Intervention 6 strongly supported cross-training within the HV Repair Cell. We recommended that OC-ALC leaders pursue changing the current hiring and operating regulations to permit formal cross-training. In the interim, we suggested the production supervisor and team leader continue with voluntary informal cross-training of aircraft and sheet metal mechanics. The results from Intervention 6 might prove useful to objectively portray that potential benefits outweigh the cost of cross-training HV Repair Cell mechanics—including highly relevant time, rework, exception-handling, risk, and position backlog improvements.

Employment of Intervention 5 characteristics entails a certain amount of training effort to teach the aircraft mechanics new tasks and time to decentralize decision-making authority within the organization. Therefore, we urged the HV Repair Cell to begin to fully qualify and utilize all aircraft mechanics as soon as possible. The findings suggested the unit would benefit from training the two aircraft mechanics currently dedicated to repairing linkages on disassembly and buildup tasks. Since this organizational change requires adequate planning, it should not occur too quickly. As low-skill-level mechanics become medium-skilled and more highly skilled, the HV Repair Cell should complete repairs more efficiently and rapidly.

Additionally, decision makers would require restraint and trust to control how to decentralize decision-making authority. Lower levels of centralization might be realized by three initiatives:

1. management taking time to clearly explain expectations and *exceptions-to-the-rule* if an emergency arises,
2. supervisors believing in subordinates' skill levels and exception-handling abilities, and
3. leadership preparing mechanics sufficiently to make good decisions, ensuring flight controls repair quality does not suffer.

The results of Intervention 7 (three eligible mechanics retire) underscored the complications organizations face as multiple employees become retirement-eligible. Before moving workers between divisions or organizations, leaders should consider the resulting percent of retirement-eligible personnel the moves create. Considering the findings from Intervention 7 should help decision makers explain the expected impact of workforce reshaping efforts and help mitigate undesirable consequences. As the number of retirement-eligible federal civilian employees increases, dealing with this type of organizational design decision will become both more difficult and more important for the DoD.

Prior to implementing any of the preceding recommendations, we advised OC-ALC decision makers to review planned and ongoing process-improvement initiatives affecting horizontal and vertical stabilizer repair and to identify similarities to the interventions performed during this study.

Understanding the enormous influence communication, information processing abilities, and organizational design have upon performance is fundamental to the

KC-135 aircraft's PDM and mission success. Effective knowledge and information transfer between personnel directly impacts PDM timeliness, cost, integration risk, and quality. Therefore, we recommend that other organizations, faced with complex processes depending on various levels of communication and skill levels, should consider the computerized organizational modeling approach to analyze and improve their processes. In particular, remanufacturing and repair facilities with 6–10 positions, 3–5 milestones, and 35–50 tasks would be great candidates for process analysis and improvement using this method. For example, should the facility remanufacture complex assets, such as complete aircraft or armored cars, the analyst should partition the analysis into easily identifiable teams operating in one or more modules of the whole, rather than trying to analyze the complete process at once. While the approach helps comprehend the process and untangle some of its complexity, one can obtain better results if part of the complexity is reduced by judicious partition of the complete operation prior to initiating the analysis.

CONCLUSIONS

Computational organizational modeling and simulation results generated by this research increased flight controls repair visibility and supplied an objective awareness for KC-135 PDM decision makers. The more transparency and utility provided, the more apt decision makers will be to examine potential organizational design modifications and assess the inherent trade-offs prior to executing changes.

The baseline model constructed for this study may be used by OC-ALC leaders and decision makers as a starting point to provide quantitative and qualitative results of future HV Repair Cell design initiatives. Furthermore, the COM results may validate organizational design adjustments leaders already believe might improve the HV Repair Cell, but are not thoroughly convinced or prepared to implement.

By simulating multiple interventions for comparison against the current flight controls repair process (depicted by the baseline), this study facilitated the HV Repair Cell's efforts to manage repair integration risk and conserve limited time and resources. Before implementing any design interventions shown to mitigate risk or decrease throughput time, HV Repair Cell leaders should also consider implementation and opportunity costs. Decision makers should weigh the trade-offs between time saved, stabilizer repair quality (project integration risk), and investment cost.

Cost benefit and risk analysis are essential to designing optimal organizational layouts. Military leaders must consider the relationship between organizational performance improvements (e.g., reduced repair turnaround time) and risk factors. The DoD emphasizes warfighter safety by managing risk. Repaired stabilizers installed on the KC-135 must perform in accordance with design characteristics, environmental conditions, operating constraints, and aircrew expectations. Otherwise, poor quality could prove fatal in combat or training environments.

In conclusion, the more visualization and transparency provided to decision makers before executing potential organizational design modifications, the better prepared they are to make those decisions. We aim to provide value by highlighting

and presenting the importance of COM because it uniquely incorporates the human element through an objective method. We hope that future efforts will employ this innovative type of modeling approach to enhance decision making and complement other DoD transformation initiatives, such as U.S. Air Force Smart Operations for the 21st Century, Lean Six Sigma, and the U.S. Navy's *AIRSpeed* program.



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STRYKER SUITABILITY CHALLENGES IN A COMPLEX THREAT ENVIRONMENT

PAUL ALFIERI AND DON MCKEON

The cost of operating and maintaining weapon systems is a large expense to the Department of Defense, and suitability performance is a major factor affecting these costs. Systems with poor suitability performance (such as low reliability, high failure rates, high spare parts usage, and low availability) are extremely difficult to support in a constrained resource environment. For many DoD acquisition programs, suitability lags effectiveness during program development. Suitability determinants (such as reliability and maintainability) are generally not addressed early enough during program development (prior to fielding) and are not prioritized with the same vigor and discipline as performance parameters like speed, accuracy, and lethality. The JROC, DOT&E, and USD(AT&L) have each called for increased attention to suitability improvement.

The primary purpose of this article was to investigate the suitability performance challenges of the recently deployed Stryker system, which was accelerated into combat in 2003. Suitability drivers were identified and possible causal factors were investigated. Several specific suitability issues for the Stryker system were revealed during this study. Stryker is performing well in the field with an Operational Readiness Rate (ORR) consistently above the required contractual value. However, a harsh combat scenario, dynamic threat environment, and extremely high tempo of operations have created unique challenges to operators and maintainers.

BACKGROUND

During his first annual report to Congress, the newly confirmed Director of Operational Test and Evaluation (DOT&E) Dr. Charles E. McQueary made three

initial observations. His first observation was that Operational Test & Evaluation (OT&E) is too often the place where performance deficiencies are discovered. Finding performance problems early in the Department of Defense (DoD) acquisition process is important—either in government Developmental Test & Evaluation (DT&E) or contractor testing. Detecting and correcting design issues early in the development process will mitigate program cost overruns and schedule delays. McQueary's second observation was that the DoD acquisition system is inherently slow, and must improve to accommodate rapid fielding of new weapons systems and new technologies. The need for rapid fielding of new technology is evident in the extended hostilities in Iraq and Afghanistan (e.g., armor upgrades for the High Mobility Multipurpose Wheeled Vehicle [HMMWV] and the new Mine Resistant Ambush Protected [MRAP] vehicle). His third observation was that operational suitability of DoD systems is too low and needs to improve. The definition of operational suitability, which can be found in the *Defense Acquisition Guidebook*, Chapter 9 (Operational Test and Evaluation), Section 9.4.5 (Evaluation of Operational Suitability), is as follows:

Operational Suitability is the degree to which a system can be satisfactorily placed in field use, with consideration given to reliability, availability, compatibility, transportability, interoperability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, documentation, training requirements, and natural environmental effects and impacts. (Defense Acquisition Guidebook, 2005)

THE COST OF LOW SUITABILITY

Low suitability is a direct contributor to higher life-cycle support costs. Data for the previous three years (2004–2006) showed that 35 percent of Initial Operational Test & Evaluation (IOT&E) phases resulted in unfavorable suitability evaluations as reported to Congress in each system's Beyond Low Rate Initial Production (BLRIP) Report (Director, Operational Test and Evaluation, 2007).

While the technical performance of weapon systems (such as speed, accuracy, and firepower) has improved significantly over the last several decades, suitability parameters (such as reliability, availability, and maintainability) have not improved. Figures 1, 2, and 3 show that this problem has been a trend for more than 20 years. All data in Figures 1–3 are based on Army Test and Evaluation Command (ATEC) programs evaluated during the years shown. Figure 1 (Duma, 2005) shows that from 1985 through 1990, only 41 percent of programs evaluated by ATEC successfully demonstrated reliability requirements during operational testing. Figure 2 (Duma, 2005) shows that between 1996 and 2000, only 20 percent of programs met reliability requirements; and Figure 3 (U.S. Army Test and Evaluation Command, 2007) shows that from 1996–2005, only 34 percent of programs met reliability requirements.

FIGURE 1. RELIABILITY DURING OPERATIONAL TESTS (1985–1990)

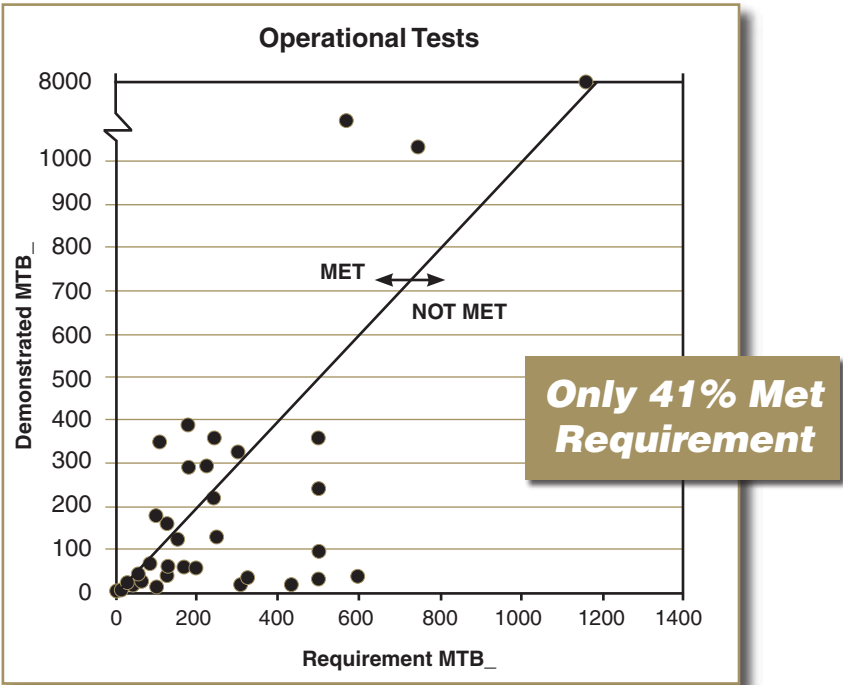


FIGURE 2. RELIABILITY DURING OPERATIONAL TESTS (1996–2000)

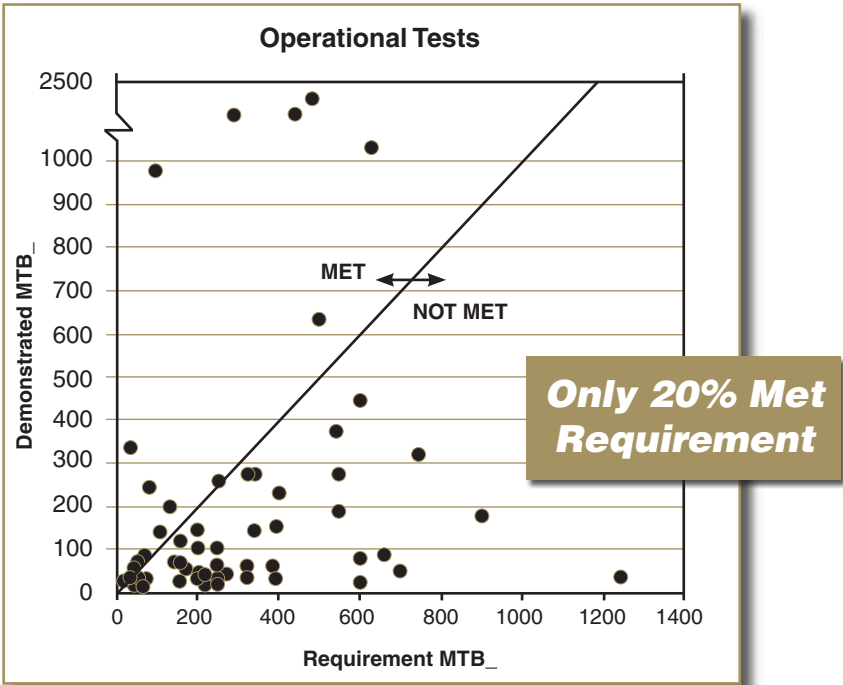
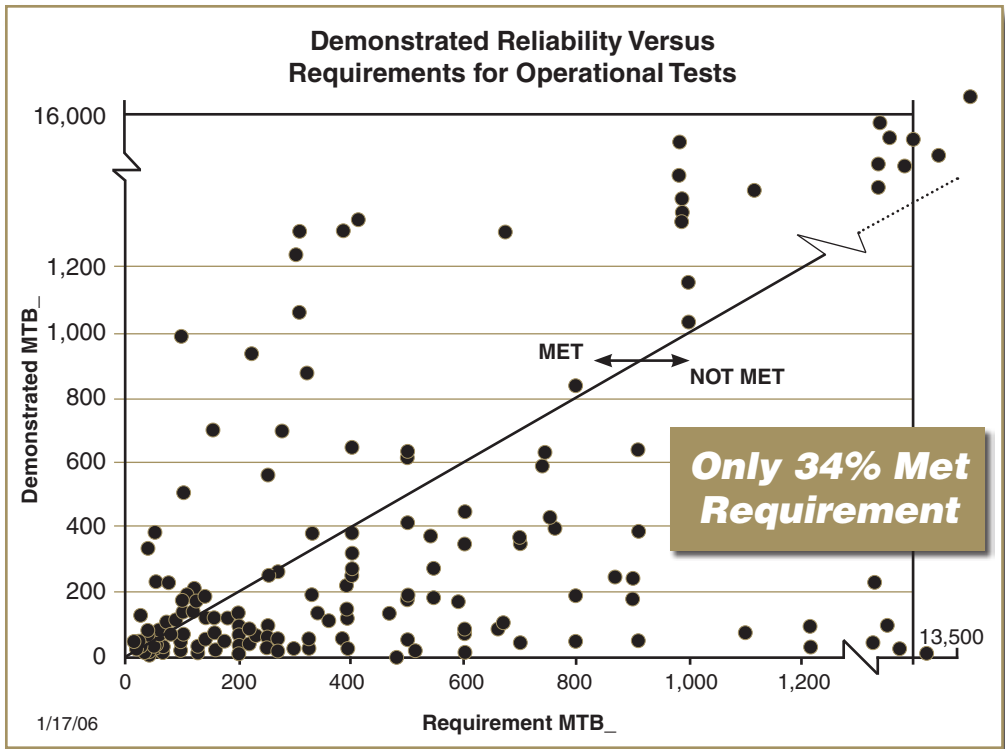


FIGURE 3. RELIABILITY DURING OPERATIONAL TESTS (1996–2005)



Stryker was a new Army program in 2000, but suitability issues were certainly not a new problem. The Defense Science Board (DSB) pointed out in 2000 that 80 percent of U.S. Army defense systems fail to achieve even half of their required reliability parameters (National Research Council, 2006). Steps have been taken to help address this concern. In November 2004, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]) directed that acquisition programs measure performance in terms of operational availability, mission reliability, and cost per unit of usage (USD[AT&L], 2004). Three months later, the USD(AT&L) issued a memorandum on Total Life Cycle Systems Management (TLCSM) Metrics, which provided specific definitions, formulas, and metrics for calculating important suitability parameters, such as operational availability and mission reliability. In 2005, the DSB recommended that DoD aggressively pursue implementation of performance-based logistics for all weapon systems. The USD(AT&L) has also directed that the TLCSM Executive Council develop a metrics handbook to be used in performance-based contracts and sustainment oversight (USD[AT&L], 2004; 2006). In August 2006, the Joint Requirements Oversight Council (JROC) mandated a Key Performance Parameter (KPP) of *materiel availability* including key system attributes of *materiel reliability* and *ownership* costs (Joint Requirements Oversight Council, 2006). These initiatives were designed to improve operational performance, establish standard suitability metrics, and reduce life-cycle support costs of new DoD weapon systems.

McQueary's third observation in his FY 2006 Annual Report is the basis for this research article. Many times systems receiving favorable effectiveness evaluations but unfavorable suitability evaluations from IOT&E are fielded before suitability shortcomings are corrected. Even though there may be good reasons for deploying these systems before correcting all suitability issues (such as an urgent combat need or the negative consequences of stopping a hot production line), fielding systems before suitability deficiencies are corrected will result in reduced operational availability and increased support costs. Low suitability directly results in increased life-cycle support costs. These costs can appear in many forms, such as: increased spares, increased contractor support, increased maintenance actions, increased maintenance man-hours, decreased reliability, decreased availability, and decreased combat capability. Costs over and above the planned costs of life-cycle support can represent a large and unbudgeted expense for DoD. This undesirable trend of low suitability during major weapon system development has been observed for at least 20 years across all Services, and this trend is not improving. For example, the reliability success rate of Army systems tested in 1996–2005 (34 percent) is lower than the reliability success rate for 1985–1990 (41 percent).

OVERVIEW

The Stryker family of vehicles was conceived as part of the Army's Transformation Campaign Plan. In 1999, General Eric Shinseki, the Army Chief of Staff, came to the conclusion that the Army had serious deployability and mobility issues (Military.com, 2007). Though the Army was capable of full-spectrum dominance, its organization and force structure were not optimized for strategic responsiveness. Army light forces could deploy rapidly, but they lacked the lethality, mobility, and staying power necessary to be effective in peacekeeping scenarios. On the other hand, Army mechanized forces possessed the necessary lethality and staying power, but required a large logistics footprint, which hindered their ability to be quickly deployed.

Subsequently, the Secretary of the Army announced a new Army vision in October 1999 to build a landpower force capable of strategic dominance across the full spectrum of ground combat operations. The key to implementing this vision was for the Army to become more strategically responsive. Stryker was designed as a full-spectrum, early-entry combat force and optimized primarily for employment in small-scale contingencies. It was developed to operate in a complex environment, including urban terrain, while confronting low- to mid-range threats with conventional and asymmetric capabilities. Requirements for the Stryker include rapid deployment, early entry execution, and the ability to conduct effective combat operations immediately upon arrival (Training and Doctrine Command, 2000a).

SCHEDULE-DRIVEN COMPROMISES

Stryker was initially deployed to Iraq in 2003 due to an urgent combat requirement. Prior to deployment, Stryker underwent an aggressive and accelerated development and

test program. The urgency of the war prevented the complete spectrum of operational testing to be completed within allowable time constraints. Only a few selected missions, types of terrain, and levels of conflict intensity were evaluated during IOT&E. Also, vehicles used did not have sufficient operating time to produce reliable repair and maintenance (R&M) data. In addition, a major configuration change was not included as part of IOT&E or PVT (Production Verification Tests) because add-on armor was not available for installation when testing was performed. The add-on armor package increased vehicle weight by approximately 20 percent. Since these tests were done in under-stressed conditions (without add-on armor), long-term durability problems were unlikely to be detected (National Research Council, 2004).

Schedule-driven compromises in T&E are not unusual to DoD programs.

Pressures on program officials to meet budgets and deadlines, due to congressional and other oversight, result in test strategies geared toward demonstrating “successful” performance. Thus, testing is often carried out under benign or typical stresses and operating conditions, rather than striving to determine failure modes and system limitations under more extreme circumstances. (National Research Council, 2006, p. 19)

According to an article printed in the *Detroit News* (2005), the Project on Government Oversight, a nonprofit government accountability organization, reported that Stryker was rushed through development, and lack of complete testing could give operators a false sense of security if failure modes are not understood (Zagaroli, 2005). However, the same newspaper article acknowledged that reports from the field overwhelmingly indicated that Stryker was performing in an outstanding manner. One of the early decisions made by the Army to support an accelerated development and deployment timeline was to rely on contractor performance-based logistics (PBL) support within the Stryker brigades. Some of the duties of the contractor personnel included conducting maintenance on the Stryker vehicle and managing the Stryker-specific supply chain. When Stryker was first deployed to Iraq, the Army did not have the institutional capability to train soldiers on conducting Stryker vehicle maintenance, and therefore faced an immediate need for contractor maintenance personnel to support the deployment (Government Accountability office [GAO], 2006a).

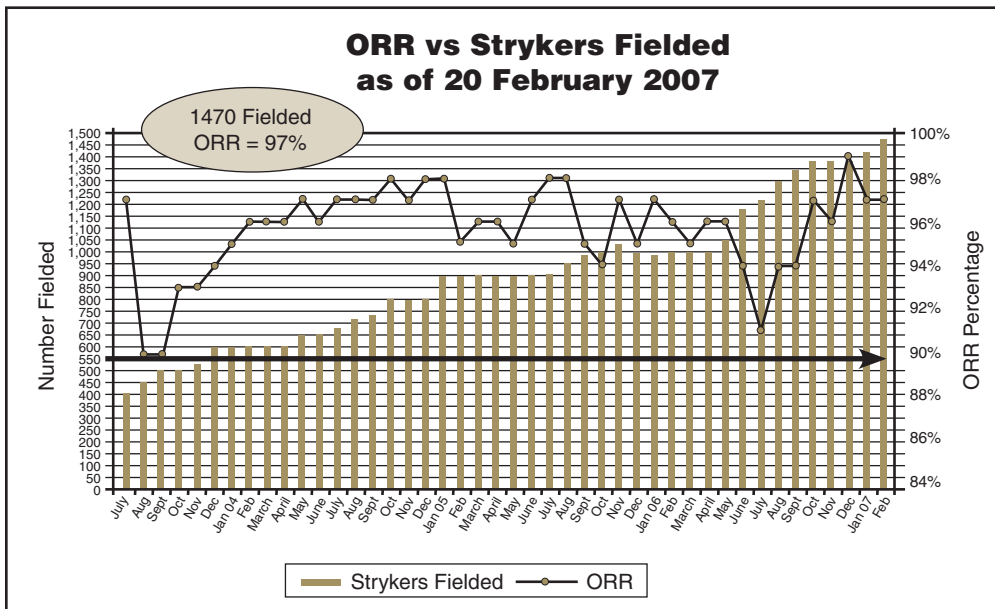
Each deployed Stryker brigade was fielded with 45 embedded vehicle maintenance contractor personnel. The Army desires to eventually replace the 45 contractors with active duty soldiers. Current plans call for implementation (removal of embedded contractors) to begin in 2008; however, the GAO reported that this goal will be difficult for the Army to achieve for several reasons. First, the 45 embedded contractor maintenance personnel must be replaced by 71 soldiers due to other collateral duties and common training requirements of soldiers. Second, the Army is very short of personnel with the five military occupational specialties for wheeled vehicle mechanics, resulting in a very difficult recruiting challenge for the Army. Currently, as reported by the *Washington Post* (White, 2007) and the *New York Times* (Cloud, 2007), the Army is indeed falling short of current recruiting goals.

OPERATIONAL READINESS

A key factor affecting Stryker suitability performance is deployed operational tempo (OPTEMPO). The program office estimates that the operational tempo is 6 times greater than the originally planned OPTEMPO. Other interviews yielded estimates of operational tempo up to 10 times the planned OPTEMPO. Harry Levins (2007) reports that vehicles in Iraq are using up 7 years of service life for each year of service in Iraq. The Government Accountability Office (GAO, 2006a), estimates that service life is being expended 800 percent faster than expected. This greatly increased operational tempo results in unexpected failure modes and increased failure rates.

A general finding of this study was that the Army is satisfied with Stryker's performance in the field. System performance in an asymmetric combat scenario under difficult environmental conditions exceeds Army expectations. Brigade commanders have consistently reported high operational readiness rates (greater than 90 percent) since Stryker was fielded, despite the fact that combat conditions in Iraq have been much different than expected (Figure 4). For example, from October 2003 to September 2005 the first two Stryker brigades that deployed to Iraq reported an average Operational Readiness Rate (ORR) of 96 percent, well above the Army-established ORR performance goal of 90 percent.

FIGURE 4. OPERATIONAL READINESS RATES



Due to the asymmetric nature of the threat forces, and to the highly adaptive nature of the enemy, the combat scenarios and operating environment have been much different than expected. According to the Stryker Interim Armored Vehicle Operational Mode Summary/Mission Profile (IAV OMS/MP) (Training and Doctrine

Command, 2000b), the Stryker planned mission profile called for operations on hard roads 20 percent of the time, and cross-country operations 80 percent of the time. The actual Stryker usage in Iraq has been almost exactly the opposite (~ 80 percent on hard roads, 20 percent cross-country). Most missions resemble police actions in the urban environment on paved roads, and crews must routinely drive over curbs and other small obstacles to navigate in the urban environment. This requires a higher tire pressure than normal causing more vibration and shock loads and high structural stress on the vehicles.

In response to the greater threat of rocket propelled grenades (RPGs), improvised explosive devices (IEDs), and small projectiles, the Army configured Stryker with an add-on slat armor package and crews added sand bags. The additional weight affected the performance of the Stryker family of vehicles as follows:

- To operate with the increased vehicle weight, the operating tire pressure had to be increased from the design specification of 80 psi to 95 psi. Stryker is configured with a centralized tire pressure system that is designed to automatically keep the tire pressure at the optimum value for specific terrain conditions, speed, and traction. The automatic inflation system was not designed to maintain 95 psi, so soldiers must set tire pressure manually and check it three times daily (Smith, 2005). The requirement to over-inflate the tires to 95 psi and to physically check tire pressure three times per day is an operational nuisance because these are unplanned, but necessary, preventive maintenance actions. Additionally, the combination of routine excessive structural stress and increased tire pressure causes unanticipated structural failures. For example, a large number of wheel spindles developed fatigue cracks and had to be replaced early. Drive shafts are also failing sooner than expected.
- Due to the issues of added weight, excessive tire pressure, and severe operating conditions, tires are also failing at a high rate. In one 96-hour test period at Fort Irwin, CA, with 16 Stryker vehicles, 13 tires had to be changed (*WorldNetDaily*, 2003). The *Washington Post* reported that 11 tire and wheel assemblies fail every day, and GAO asserts that each Stryker vehicle is going through one tire per day on average (Smith, 2005). The additional maintenance actions (checking/adjusting tire pressures and changing tires) are extremely burdensome to the crews since changing tires is not crew-level maintenance and requires special tools.
- The 5,000 pounds of armor to counter RPG threats is generally effective but has many negative operational consequences, such as limited maneuverability, increased component stresses, safety issues, and transportability issues. The extra weight and increased physical dimensions caused by the add-on slat armor adversely impacts performance, especially when maneuvering in spaces with narrow clearance and maneuvering in wet conditions. Operations in soft sand or wet conditions (mud) place additional stress on engines, drive shafts, and differentials; and these items have experienced higher than normal failure rates (Dougherty, 2004).

- Also, the slat armor causes multiple problems for safe and effective operations. Slat armor can deform during normal operations, sometimes blocking escape hatches and the rear troop egress door. The armor adds approximately 3 feet to the vehicle's width and can interfere with the driver's vision. Armor also makes it difficult for others to see the Stryker at night, which is a safety hazard in the urban environment. The armor is very heavy for the rear ramp and strains lifting equipment, requiring crews to sometimes manually assist raising or lowering the rear ramp. The armor attaching bolts on the rear ramp can break off with normal use (increasing the maintenance burden) and may generate an unsafe condition. In addition, slat armor prohibits normal use of storage racks, which may impact operations. Lastly, slat armor affects the transportability of the vehicle in a C-130 cargo aircraft, since the extra weight greatly reduces transport range (GAO, 2004).

A very important contractual requirement for the prime contractor, General Dynamics Land Systems (GDLS), is to maintain an Operational Readiness Rate (ORR) of 90 percent or better . . . Since initial deployment, Stryker has routinely exceeded this operational requirement.

Even though these operational issues caused by the add-on slat armor place additional maintenance burdens on crews, Stryker has been reported to be well-suited for the urban fight. Unlike the M-1 tank, Stryker can operate very quietly at high speed, which can be a tremendous tactical advantage (Tyson, 2003). Most Army personnel interviewed felt strongly that Stryker's tactical performance in the urban environment in Iraq was significantly better than the M113A3, HMMWV, Bradley Fighting Vehicle, or Abrams Tank.

In response to unanticipated urgent combat needs in Iraq, some engineering improvements (configuration changes) were performed on the Stryker since deployment. Since the Army did not buy the technical data package because of its cost, these engineering changes have resulted in increased costs and potential risks (GAO, 2006b). The GAO reports that current DoD acquisition policies do not specifically address long-term technical data rights for weapon system sustainment. As part of the department's acquisition reforms and performance-based strategies, DoD has de-emphasized the acquisition of technical data rights. The GAO has recommended that DoD recognize the need for the acquisition of technical data rights and asserts that without technical data rights, DoD may face challenges in efficiently sustaining weapon systems throughout their life cycle.

A very important contractual requirement for the prime contractor, General Dynamics Land Systems (GDLS), is to maintain an Operational Readiness Rate (ORR) of 90 percent or better. This requirement pertains only to the base vehicle

configuration and does not include Government-Furnished Equipment (GFE). Since initial deployment, Stryker has routinely exceeded this operational requirement. The Cost Plus Fixed Fee (CPFF) contract effectively motivates GDLS to exceed 90 percent ORR; however, the contract is not necessarily effective at controlling support costs, and this may be a risk to the government (U.S. Army Audit Agency, 2005). One example of this is the repair and replacement of a high failure item, for example, cracked hydraulic reservoirs in the power pack. Maintenance procedures call for the entire power pack to be replaced as a unit, rather than removing and repairing/replacing the hydraulic reservoir within the power pack. Replacing entire power packs (instead of repairing/replacing hydraulic reservoirs within the power packs) results in shorter down-times and higher ORR, but it also requires more power packs (very large, expensive units) to be purchased and shipped to operating bases and forward maintenance facilities. The net result is that higher operational readiness is being purchased with increased transportation and storage costs.

SUSTAINABILITY CHALLENGES

Since Stryker's initial deployment was accelerated to meet an urgent combat need, the Stryker program team was performing the following activities concurrently: testing, production, fielding, training, and combat. In addition to the many challenges caused by these concurrent activities, the threat and operational environment in Iraq were different than anticipated, as previously mentioned. Several other factors added to the difficulty of maintaining Stryker vehicles in the field.

First, the Interactive Electronic Technical Manuals (IETMs) were not mature at the time of initial fielding. Many maintenance procedures could not be performed based on the IETMs because they were either not characterized correctly or crews were not adequately trained on their use. This situation led to *tribal system maintenance*, where units depended on soldiers and contractors with experience on similar systems (like the M-113 armored personnel carrier) to figure out how to perform the maintenance actions correctly.

Second, since a large portion of maintenance actions was supported by contractor personnel, soldiers developed a *rental car mentality*. This lack of *ownership mentality* resulted in soldiers being overly dependent on contractor personnel to perform routine preventive maintenance actions, such as checking fluid levels. One vehicle was lost because the pre-mission engine oil check was ignored.

FINDINGS

Stryker is performing well in the field. The system is exceeding expectations of Army management and soldiers. In spite of a changing threat environment (improved IEDs and excessive operations in the urban environment) and major configuration changes (5000 pounds of add-on armor), Stryker is accomplishing its mission. The Operational Readiness Rate has consistently been over 90 percent.

Due to the increased threat of RPGs and IEDs, Stryker was outfitted with an add-

on armor package. The additional 5,000 pounds of armor has been generally effective at mitigating the threat, but has resulted in some negative operational/support consequences. The extra weight requires increased tire pressure, which causes operational problems and more structural stresses. Additionally, the armor limits crew visibility during operations and restricts airlift transportability on a C-130 aircraft.

Army decisions regarding contractor logistics support may remain with the Stryker program for years. When Stryker was first deployed to Iraq in 2003, the Army faced an immediate need for contractor maintenance personnel to support operations (45 vehicle maintenance personnel per brigade). The Army plans to eventually replace the 45 contractor maintenance personnel with soldiers, but it will take approximately 71 soldiers per brigade to perform the same level of vehicle maintenance as the 45 contractors because of other duties and responsibilities of active duty personnel. The current plan is to begin the transition to soldier maintenance in 2008, but the transition will probably be very difficult to implement due to the poor recruiting/retention outlook in general, and to the shortage of appropriate active duty maintenance personnel.

The general issue of suitability shortfalls in DoD acquisition programs is recognized at high levels of management and is being addressed.

Stryker program development was accelerated to meet the Army's combat needs in Operation Iraqi Freedom. Due to the compressed developmental schedule, Stryker DT/OT was unable to fully test all configuration changes. DT revealed relevant problem areas, but there was insufficient time or priority to correct all problems before OT and fielding.

For many DoD acquisition programs, the maturity of suitability parameters lags the maturity of effectiveness parameters during program development. Suitability determinants (such as reliability and maintainability) are not addressed early enough and are not prioritized with the same vigor and discipline as performance parameters like speed, accuracy, and lethality.

The general issue of suitability shortfalls in DoD acquisition programs is recognized at high levels of management and is being addressed. JROC, DOT&E, and USD(AT&L) have each called for increased attention to suitability improvements. For example, a new requirement exists for a Materiel Availability KPP.

The operational tempo of Stryker vehicles in Iraq far exceeds original usage estimates by at least 500 percent. Also, the mission profile of Stryker is much different than expected (80 percent on paved roads). This, in combination with the added weight of slat armor, has resulted in excessive stresses to the suspension, wheels, and tire assemblies causing increased failure rates of these items.

Since Stryker was fielded in 2003 in Iraq, the operational situation has been dynamic, unpredictable, and volatile. Four factors have made it very difficult to obtain complete and reliable data for trend analyses. The first factor is the rapidly evolving

adaptive nature of the threat in an asymmetric combat environment. The second factor is that the operational environment for deployed Stryker vehicles is more severe than anticipated during design/development. The third factor is that, in response to the first two factors, configuration changes have precluded a stable baseline. The fourth factor is that in a dangerous combat scenario, recording and reporting data is not a high priority for operational crews.

CONCLUSIONS

In response to Operation Iraqi Freedom, there was an urgent operational need to deploy the Stryker system. Therefore, the development and test programs were greatly accelerated to get Stryker units into the field as quickly as possible. At the same time, the mission was changing as the threat quickly adapted and evolved in this asymmetric combat environment. The continually changing configuration baseline and changing tactical conditions made it very difficult to evaluate or predict reliability and suitability performance across all mission scenarios. The operational situation has been dynamic, as well as unpredictable and volatile, because Stryker was deployed in operational combat conditions that were different from, and much more complex than, those originally anticipated. In many ways, the system was not adequately designed for the actual threat it is facing today. However, this is certainly not the first time nor the last time this type of situation will occur. As a result, this case is a good example of how incomplete or incorrect maintenance/support planning can significantly add to the logistics burden. Due to the adaptive nature of the threat in the asymmetric warfare environment of Iraq and Afghanistan, our acquisition managers and operational planners are challenged to consider more complex and dynamic combat scenarios and contingencies than ever before.



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Image designed by Jim Elmore

INDEPENDENT PROGRAM OVERSIGHT: AN ANSWER FOR MAJOR WEAPONS SYSTEMS' SUCCESS?

EMORY MILLER

The Department of Defense (DoD) has a long and consistent history of major program successes and failures. Unfortunately, because of the nature, size, and complexity of DoD endeavors, when projects fail losses are great to both the warfighter and the taxpayer. The question that begs an answer is: Why do DoD's programs and projects continue to fail considering the department's investment in program management and its long history of lessons learned in acquiring major weapons systems? Research suggests that the answer might lie in the execution of the programs and lack of independence in program oversight.

Perfect storms occur on the open seas and within the confines of government. It would be very hard today for even a casual reader of government reports and policies to ignore the trends in thought revolving around program oversight. The White House, the Department of Defense, the Government Accountability Office (GAO), research organizations, and program offices themselves—all tell the same story that programs are failing because, among other factors, they are not establishing and conducting adequate levels of oversight. DoD's major weapons systems are targets for this criticism, having struggled for years to meet program and performance goals. Is this true? And if so, is there a construct for oversight that makes sense and delivers results in the form of desired program outcomes?

A LEGACY OF DIFFICULTY

Department of Defense investments in major weapons systems are significant: \$157 billion in fiscal year 2006 and a projected estimate of \$188 billion in 2011. Obviously, the management of these large investments is critical to the success of the warfighter and the department as a whole as it addresses a growing number of threats to our nation's security. Yet, the GAO repeatedly describes problems with the development, acquisition, and delivery of major weapons systems. In an abstract of an April 2006 report to Congressional Committees, the GAO states, "Numerous programs have been marked by cost overruns, schedule delays, and reduced performance" (GAO, 2006, Highlights Section, ¶ 2). In 2006 alone, GAO issued 12 reports addressing issues impacting major program successes. In most of the reports, the GAO recorded deficiencies in the application of fundamental principles of program management.

Program and project failure is not unique to DoD or the rest of government. Agency inspectors general consistently report agency failures in delivering program outcomes on time and within budget. The private sector appears to do no better. After acknowledging some improvement in recent program management successes, David Rubinstein (2007) reports in a *Software Development (SD) Times* article that only 35 percent of software projects are successfully meeting cost and schedule goals and customer needs.

THE PM PARADOX

Program management is a mature and proven discipline that represents a long history of business lessons learned. It is constantly updated to reflect the latest management trends and best practices. It applies to all levels of an organization—project, program, and enterprise—wherever business processes are performed. It is valued by both the public and private sectors and widely implemented as a discipline that enhances successes. Yet, programs and projects continue to fail. Why?

THE POSTULATION

Programs and projects fail because they are not executed well. And they are not executed well because decision makers (i.e., sponsoring executives and program managers) are not informed with timely, accurate, and helpful information.

PROGRAMS AND PROJECTS PROGRESS DOWN PATHS, NOT STRAIGHT LINES

Yes, there are other reasons programs and projects fail. Defense program managers list requirement changes and budget instabilities as two of the most difficult and frequent challenges to program success. Technology risk is another. But *informed* decision making can mitigate these influences and bring resources to bear at the right time to impact program progression.

Decision making is a fundamental responsibility of government that should not be outsourced or neglected. Military and government decision makers must be informed and proactive to steer programs and projects to successful conclusions. *Steer* is the operative word because projects do not proceed down straight lines to their conclusion. They wiggle. A project plan lays out a scenario of planned activities, milestones, and outcomes; but projects, after launch, are influenced by real-world events such as budget fluctuations, political pressures, and changing requirements. Program managers must know the true and real-time status of their programs or projects and actively mitigate detrimental factors to keep them on a *path* to deliver established cost, schedule, and performance goals. According to the GAO, “Without effective controls that require program officials to satisfy specific criteria, it is difficult to hold decision makers or program managers accountable to cost and schedule targets” (GAO, 2006, What GAO Found Section, ¶ 3).

POOR DECISION MAKING IS NATURAL

In their *Harvard Business Review* article, “Delusions of success: How optimism undermines executives’ decisions,” Dan Lovallo and Daniel Kahneman (2003) state that decision making is flawed by cognitive biases and organizational pressures to play up the positive. For DoD initiatives, the faulty thinking begins when investments are made. To make projects attractive, we tend to play up their benefits and downplay their risks. After launch, we cling to our predictions at all costs because we believe in our mission and don’t want to admit any possibility short of full success. We are inclined to ignore information that doesn’t support our desired progress toward project milestones. We are also inclined to exaggerate our own abilities and control.

If we can shed our natural biases, we still falter because we are not informed with timely, accurate, and helpful information. There are many reasons:

- No bias-free and conflict-free entity is focused on cost, schedule, and performance targets.
- No one is coordinating activities and information flow among multiple sources of support in a fair and impartial manner.
- There is no single unbiased source for advice on program performance and progress.
- Highly experienced and skilled program management support is not available.

THE CASE FOR INDEPENDENCE

Our argument on the importance of being informed takes on greater meaning when we consider that government moves forward and accomplishes its objectives through **chunks** of work we call initiatives, programs, and projects—activities that equate to billions of dollars of investments. Government decision makers are stewards of the government’s vast resources and capabilities. Being informed and making

timely decisions based on accurate and helpful data are key to the success of programs and projects and to the stewardship of these resources.

LET'S REVIEW

- The government accomplishes work through launched initiatives also called programs.
- Reviewers (the GAO and IGs) say we don't manage our initiatives well.
- We apply program management principles, but we still struggle to deliver successful programs.
- We struggle because we optimistically assume that our plans and predictions will come true.
- We progress down paths influenced by the real world.
- We are not able to make good decisions because we are not informed. And we are not informed because we don't have timely, accurate, and helpful information.

The questions we must ask then are: "How do we become and stay *informed*? What can we put in place that will assure us of timely, accurate, and helpful information?" The answer is Independent Program Oversight (IPO).

WHAT IS INDEPENDENT PROGRAM OVERSIGHT?

Independent Program Oversight is a **support** function performed by experienced and skilled practitioners in program management who are free of biases, conflicts of interests, and political influences. The IPO's job is to keep government decision makers informed of the true status of their programs, including budget status, requirement changes, technology risks, and progress toward cost, schedule, and performance goals. The IPO also advises decision makers on the maturity of business processes that could impact program performance and success. What defines an IPO is its independence. By design, the IPO is free of interests that could skew its judgment and value to the government. GAO has pointed to the need for an IPO type of function since 2003. In a memorandum to the Congressional Committees, GAO states, "The department's leadership needs to put necessary controls in place to ensure decision makers could make *informed* [italics added] judgments" (GAO, 2007a, p. 6).

IPO IS

IPO can be thought of in a number of ways:

1. Philosophically, it is the concept that values the independence of program management in its application throughout the enterprise. Greater transparency and understanding of the project's facts and status occur whenever independent judgments are made.

2. Practically, IPO consists of an office that provides **support** to a government decision maker such as a program executive officer or a program manager. It is staffed with experienced practitioners in program management who have free access to information and data pertaining to a program (no matter the source), and are **fire-walled** from detrimental influences that skew judgment. IPO is a trusted advisor to government and mediator to private interests such as contractors and subcontractors. IPO's main focus is the success of the program.
3. From an acquisition strategy perspective, IPO can be thought of as an approach that identifies and separately competes a set of requirements for IPO services. In other words, a large weapons systems requirement could consist of a solicitation for development, testing, and deployment and a companion solicitation for independent program oversight support.

IPO IS NOT

IPO is not a compliance or auditing activity that assesses what was done or not done in the past against established standards. In contrast, IPO looks forward and performs assessments, reviews, and evaluations to influence interactively the execution and performance of a program as it evolves.

IPO is not another level of oversight or an additional layer of program management services. IPO might include the traditional services found in a program management office (PMO) if those services are not otherwise present in the program office—given that any major program requires a robust and mature level of program management. Regardless of the construct, the IPO function must be designed and implemented to be rigorously independent.

TYPICAL FUNCTIONS OF AN IPO

IPO is a highly interactive and real-time support function focused on the success criteria and progress of a program and its associated projects. It is outcome-driven. IPO's job is to make the PEO or PM successful. Typical IPO functions are

- validating cost estimates, methodologies, and research;
- assessing maturity and sufficiency of program management capabilities;
- assessing cost and schedule compliance, including earned value methodology approach and effectiveness;
- monitoring budget and requirement changes that could potentially impact program goals;
- evaluating program risks and risk mitigation plans, including risks associated with technology implementations;
- assessing progress toward program objectives and outcome deliveries; and
- providing advice and recommendations on progress toward cost, schedule, performance, and outcome goals.

CONTRACTUAL CONSIDERATIONS

IPO requires contractual activity in two important ways:

1. The overall acquisition strategy for a major weapons systems endeavor must include an independent solicitation action for the services of highly skilled and experienced program management practitioners.
2. The strategy must also include the provision or modification of contracts to permit IPO access to relevant information and data concerning a program's progress toward its goals.

Additionally, sponsoring organizations should establish agreements to convey executive commitment and encourage joint understanding of expectations and a win/win spirit among the key players: the PEO, the PM, the customer, the contractors, and their subcontractors. This could be part of DoD's new policy on weapons systems acquisitions. The GAO Congressional Committees report states:

As part of DoD's strategy to enhance the role of program managers in carrying out its major weapons system acquisitions, the department has established a policy that requires formal agreements among program managers, their acquisition executives, and the user community intended to set forth common program goals (GAO, 2007a, p. 2).

WHAT DO OTHERS SAY?

The benefits of independence in program management and concept of independent program oversight are widely recognized in the public and private sectors. A 2005 Gartner article entitled *Project Management Office: The IT Control Tower*, states: "Enterprises need an in-house or third-party capability for scrutinizing schedule slippages, changes, and other project issues" (p. 35). It also says, "Project office oversight of ESPs [external service providers] will help 35 percent of IT organizations avoid major disruptions to business strategies and IT operations through 2009" (p. 4).

A February 2005 case study on Customs and Border Protection (CBP) by the META Group (since acquired by Gartner, Inc.) states:

R-G worked very hard at helping the CBP and integrator manage and report information more accurately, so that they were effective at containing the problem and keeping the program on track ... This example indicates one of the benefits of using a separate company to oversee the program and to provide better accountability and discipline (Ballou, 2005, p. 2).

A GAO report on DoD weapon systems acquisition says "DoD ... must establish stronger controls to ensure that decisions on individual programs are *informed* (italics added) by demonstrated knowledge" (GAO, 2007c, p. 61).

A survey of senior IT executives lists the following key finding:

“More than 70 percent of survey participants indicated that they valued the concept of an independent, separate group of people designated to assist them in overseeing large-scale initiatives, as opposed to the oversight being performed by the same people doing the implementation” (Robbins-Gioia, 2007, p. 4).

In May 2007, a GAO report included the following statement on what is needed to improve management and oversight in order to better control the way DoD acquires services:

“Managing and assessing post-award performance entails various activities to ensure that the delivery of services meets the terms of the contract and requires adequate surveillance resources, proper incentives, and a capable workforce for overseeing contracting activities. If surveillance is not conducted, not sufficient, or not well documented, DoD is at risk of being unable to identify and correct poor contractor performance in a timely manner and potentially pay too much for the services it receives” (GAO, 2007b, p. 10).

CONCLUSIONS

Perfect storms come in the form of debates also. There has always been debate in the federal acquisition community on the role of government versus the role of contractors. Over time, we have shifted and reshifted responsibilities for program outcomes between the public and private sectors. A key responsibility that will **never** move to the private side because it is an inherently governmental function, is decision making. Government officials and military leaders are stewards of taxpayer resources and government capabilities. In no place is this more evident than in the conduct and delivery of DoD’s major weapons systems. It is here that decision making must be focused, accurate, and timely. Independent program oversight provides the honest assessments critical to clear understanding and thought essential to good decision making. Good decision making delivers program results and outcomes.



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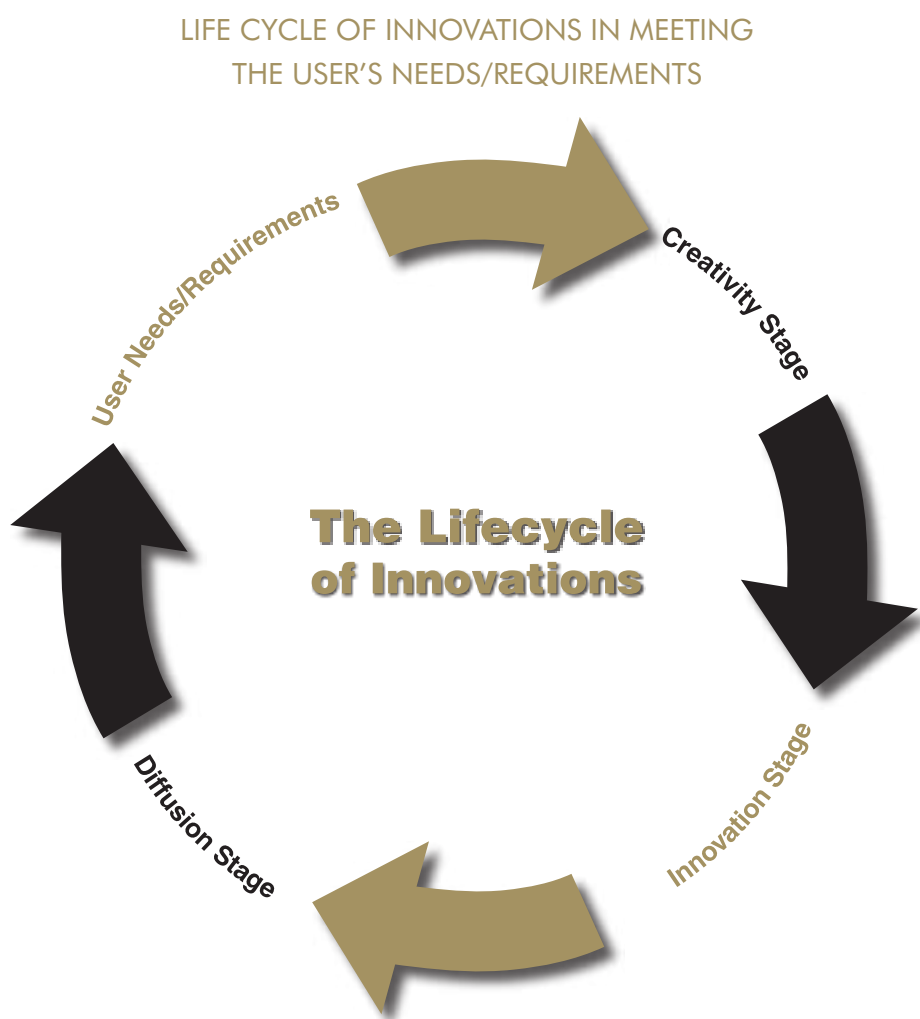
THE LIFE CYCLE OF INNOVATIONS

JEROME H. COLLINS AND JOSEPH MOSCHLER

Innovations have been shown to have a positive influence on the success of organizations. However, without individual and group creativity, innovations cannot occur. Likewise, the benefits of those innovations will never be fully realized in an organization unless each innovation is adopted and diffused throughout the organization. This article will lead to a better understanding of the relationship between creativity, innovation, and diffusion in the context of the *The Life Cycle of Innovations*. Much can be learned from the research that has been done on the subject of innovation. Throughout this article, the findings of that research will be presented and conclusions drawn for further consideration by senior leaders of the defense acquisition workforce.

What is an innovation and how does it happen? With so much of the warfighters' present and future requirements depending on the innovativeness of individuals and organizations within the Department of Defense Acquisition, Technology and Logistics (DoD AT&L) workforce, the question of how innovativeness occurs is a vitally important question to consider. Extensive research has been performed within the private sector, which can be used to answer the questions we have concerning innovation. For instance, we know that an organization's long-term success is linked to its ability to provide innovations that meet a user's demands (Chandrashekar, Mehta, Chandrashekar, & Grewal, 1999). Many research studies have identified innovation as having a positive effect on organizational performance (Damanpour & Evan, 1984; Damanpour, Szabat, & Evan, 1989; Khan & Manopichetwattana, 1989; Zahra, de Belardino, & Boxx, 1988; Han, Kim, & Srivastava, 1998). Therefore, an understanding of how innovations are created inside an organization and distributed to users, such as warfighters, is a starting point for understanding how to increase organizational performance. In this article, innovation will be explored in the framework of an innovation life cycle. The life cycle begins

with the creativity stage, then proceeds to the innovation stage, and lastly to the diffusion stage. This is shown in the flow chart, which depicts the life cycle of innovation in meeting the user’s needs/requirements.



As a beginning to the study of each of the three stages in *The Life Cycle of Innovations*, the stages should be defined.

THE FOUNDATION OF INNOVATION

The foundation of innovation is creativity (Scott & Bruce, 1994). Creativity is simply the production of novel, appropriate ideas in any realm of human activity, from science, to the arts, to education, to business, to everyday life (Amabile, 1997; Mumford & Gustafson, 1988). Innovation flows from the creativity of individuals and is defined as the successful implementation of the novel and appropriate ideas (Ama-

bile, 1997). In other words, innovation is the implementation of creativity. However, just because a creative idea is implemented, does not mean that it has been adopted by a user or users. This occurs when the diffusion of the innovation occurs. Diffusion is the process by which an innovation spreads among a group of individuals (Rogers, 1962). Now that we understand the definitions of creativity, innovation, and diffusion, let us examine each of these more thoroughly.

CREATIVITY

Individuals have been shown to have two styles of creativity: adaptive and innovative (Kirton, 1976). In problem solving, individuals who are adaptors prefer to do things better within the generally accepted boundaries of theory or policy. On the other hand, innovators prefer to do things outside of the boundaries or *differently*. In fact, Kirton (1976) proposed that individuals can be viewed as being anywhere from those that are able to do things *better* to those that are able to do things *differently* for solutions they have to similar problems. Each of these styles of creativity is important in different respects to the process of innovation. For instance, if a completely new innovation is sought by an organization, then it would be better to assign an individual who is an innovative decision maker to the task. However, if an organization would like to adapt a current innovation to other uses, then an adaptive decision maker may be better suited. A recent example of this is the Joint Strike Fighter aircraft competition. Both Boeing and Lockheed Martin developed unique designs for the Short Take-off and Vertical Landing (STOVL) version of the aircraft (Pipinich, 2006). However, vertical lift in the Boeing design was provided by redirecting thrust from the engine. This technology was already being used in one of Boeing's other aircraft platforms, the AV-8B aircraft. This could be characterized as an adaptive approach to the design. In comparison, the Lockheed Martin design used a novel approach by having a lift fan driven off the engine to provide vertical lift. This approach could be characterized as an innovative style.

The management of an individual's attention is one of the most critical aspects of managing creativity (Van de Ven, 1986). An individual's attention is usually split between several different competing priorities. Therefore, in most organizations, individual creativity is squelched to the point where only crisis can stimulate action (Scott & Bruce, 1994). A climate for creativity, and subsequently innovation, must exist in organizations. Individuals should be given the time and resources to create innovative solutions to problems. For instance, the Naval Air Systems Command (NAVAIR) is implementing the principles of Lean and Six Sigma under a program titled *AIRSpeed*. This program is intended to improve the business and technical processes that NAVAIR uses to acquire and support weapon systems for the U.S. Navy. Individuals are assigned to the *AIRSpeed* Program on a full-time basis to work specific initiatives so they are not distracted by other priorities and can work at their most creative best.

But why are individuals creative? Creativity within individuals is comprised of three components (Amabile, 1997). These three components are the precursors to individual creativity: expertise, creative thinking, and task motivation. The foundation

for all creative work is expertise (Amabile, 1997). Individual expertise includes the factual knowledge, technical proficiency, and special talents in the work area. These are essential in an individual before creativity can take place. Next, creative thinking is the skill necessary to look at a problem in a different way, with a work style conducive to persistence and energy. Expertise and creative thinking are components of what an individual is capable of doing, but task motivation determines what an individual will actually do. Creativity cannot be forced on individuals. Individuals are motivated to be creative for two reasons: intrinsic motivation and extrinsic motivation (Amabile, 1997). Intrinsic motivation comes from individuals who work on something because they enjoy what they are doing. Extrinsic motivation comes from individuals who work or create because they are being evaluated on their work or from promises of a reward. Positive evidence shows that people are most creative when they are primarily, intrinsically motivated (Amabile, 1983; Amabile, 1996). This is to say that individuals will be their most creative when they enjoy what they are doing.

INNOVATION

Creativity has been shown to be the development of ideas. Innovation takes those ideas and puts them into action. Innovations can be separated into three basic categories: (a) line-extensions, (b) me-too products/services, and (c) new-to-the-world products/services (Lukas & Ferrell, 2000).

Line-extensions. These products/services expand on an existing product/service that an organization produces. For instance, the EA-18G aircraft is a line extension of the existing F/A-18 E/F aircraft program.

Me-too products/services. These products/services are new to the organization, but are not new to the marketplace. The implementation of Enterprise Resource Planning (ERP) within certain Department of Defense organizations is an example of a me-too service. ERP migrated over from the commercial world into government agencies as an innovation that was new to the government, but not new to commercial industry.

New-to-the-world products/services. These products/services are new to both the firm and the marketplace. For instance, the M-16A1 assault rifle was a new-to-the-world item for both the manufacturer and the warfighter in the 1960s when it was introduced.

CHARACTERISTICS OF ORGANIZATIONAL MOTIVATION

Just as with individual creativity, organizations have certain characteristics necessary for innovation to occur. The three characteristics include organizational motivation to innovate, resources, and management practices (Amabile, 1997). The support for innovation must come from the highest level within the organization. The degree to which individuals perceive the organizational climate supporting innovation is positively related to their innovative behavior (Scott & Bruce, 1994). Management within an organization can support innovation by placing a high value on innovation,

by encouraging risk taking, by having a sense of pride in the individuals doing the innovating, and by taking an offensive strategy to lead into the future (Amabile, 1997; Cummings, 1965).

An organization must offer its resources to foster great innovation (Amabile, 1997). These resource elements include sufficient time to be creative, an adequate number of creative people assigned to the task that have expertise, material resources, relevant information, and any training that might be necessary to aid in the innovative process.

Management practices for innovation include issues related to leaderships' interaction with the individuals and work teams within the organization that are performing the innovative tasks (Amabile, 1997). The quality of leader-member exchange between an individual and his or her supervisor is positively related to the individual's innovative behavior (Scott & Bruce, 1994). Furthermore, the degree to which a supervisor expects a subordinate to be innovative is positively related to the subordinate's innovative behavior.

DIFFUSION

Diffusion can be viewed as a process that an organization goes through to adopt an innovation (Roger, 1962). Adoption of an innovation within an organization occurs along a time continuum with some individuals accepting the innovation very early after being introduced to it and others taking longer, with the great majority of individuals being in the middle of the time continuum. Furthermore, the process that each individual will go through to adopt an innovation is basically the same. The adoption process proceeds from awareness, to interest, then evaluation and trial, and finally adoption (Rogers, 1983).

The stages of innovation and the antecedents for each of these stages are summarized in Table 1.

TABLE 1. THE ANTECEDENTS OF CREATIVITY, INNOVATION AND DIFFUSION

Creativity	Innovation	Diffusion
Individual expertise	Line extension	Awareness
Individual creative thinking	Me-too-product/service	Interest
Individual motivation (intrinsic and extrinsic motivation)	New-to-the world product/service	Evaluation and trial
		Adoption

LEADERSHIP IMPLICATIONS

Since innovation is so important to performance of our DoD AT&L organizations, several implications for the leadership of the AT&L workforce may be drawn

from the research on creativity, innovation, and diffusion. First, creativity within an organization must be promoted at the highest level and throughout the organization. The degree to which individuals perceive organizational climate as being supportive of innovation is positively related to their innovative behavior (Scott & Bruce, 1994). Also, the more a group's culture is characterized by innovativeness, the greater the number of innovative outcomes the group will produce (Hurley & Hult, 1998). As an example, Toyota Material Handling USA has an employee suggestion system with a goal of three suggestions per associate per month. This typically equates to 1,200-1,500 actual plant-wide suggestions per month (Gembutsu, 2007). This is just one opportunity the company uses for encouraging its employees to be innovative. However, organizational commitment to innovativeness in the long term may conflict

Since individual creativity comes from individuals with expertise, creative skills, and task motivation, then it is important for leadership to focus on finding individuals with these qualities or developing these qualities in individuals within the organization.

with organizational performance in the short term. For instance, encouragement a leader gives to a team to take risk is positively related to innovativeness (Sethi, Smith, & Park, 2001). However, the reality is that if products/services fail the user, then the performance of the organization suffers. Therefore, organizations are less likely to take risk knowing that the performance of the organization may suffer. Second, leadership and the individuals that are innovating must communicate. The quality of leader-member exchange between an individual and his or her leader is positively related to the individual's innovative behavior (Scott & Bruce, 1994). Also, the degree to which a leader expects an individual to be innovative is positively related to the individual's innovative behavior (Scott & Bruce, 1994). For instance, it has been shown in the private sector that product innovativeness increases as the level of senior management monitoring increases (Sethi, Smith, & Park, 2001). All of these studies support the importance of leadership support for innovativeness. Third, leadership within an organization should take special care when selecting individuals who will be innovators for the organization. Since individual creativity comes from individuals with expertise, creative skills, and task motivation, then it is important for leadership to focus on finding individuals with these qualities or developing these qualities in individuals within the organization. For instance, if leadership determines that an individual has the intrinsic motivation and creative skills to innovate, but lacks the expertise, then training can be provided to that individual to develop the expertise. Furthermore, leadership should take special care in selecting individuals that are able to work together on innovations. It has been shown that certain aspects of group dynamics have an effect on innovativeness (Scott & Bruce, 1994; Hurley & Hult, 1998;

Sethi, Smith, & Park, 2001). For instance, the more a group’s culture emphasizes participative and open decision making, the greater its cultural innovativeness (Hurley & Hult, 1998). Therefore, leadership in an organization should encourage these qualities in the teams that they organize to develop new innovations. Empowerment of these teams to implement innovations and creative solutions is also critical. This empowerment gets results faster and it can be a significant motivating factor for the team members (Gembutsu, 2007). Those closest to the problems and with the most expertise should be able to make decisions to implement innovative changes. Table 2 summarizes the leadership implications for innovation within an organization.

TABLE 2. LEADERSHIP IMPLICATIONS OF INNOVATION WITHIN AN ORGANIZATION

Motivation to Innovate	Resources to Innovate	Management Practices
Top management support	Time	Interaction between individuals and supervisor
Encouragement to risk take	Expertise	Interaction between team members
Corporate strategy to innovate	Training	Expectation of individuals to innovate
	Materials	
	Information	

CONCLUSIONS

Through various research studies, innovations have proven to be essential to the long-term survival of any organization. In order for an organization to understand and implement *The Life Cycle of Innovations*, it must first understand important stages in the life cycle: creativity, innovation, and the diffusion of the innovation. Leadership in an organization has an important function to perform in each of these steps to insure the individual’s needs, as well as the team’s needs, are met, creating an atmosphere where innovation is encouraged and valued. Also, once the innovation has been developed, leadership must insure that the steps are taken to diffuse the innovation to the appropriate users. With this understanding of what innovation is and how it occurs within an organization, the DoD will have the basis for accelerating innovation and change to the warfighter into the future.



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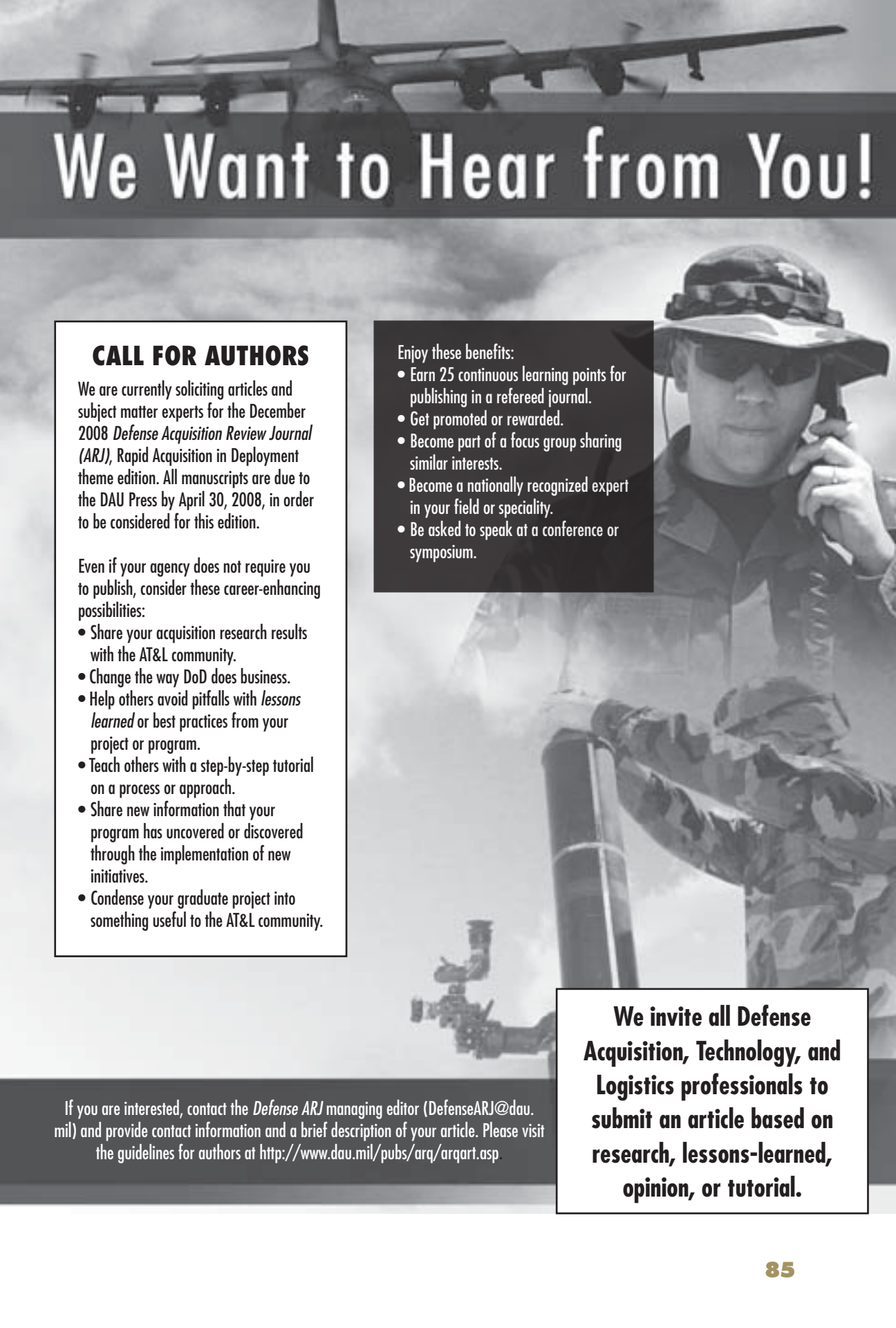
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