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DAUAA 2010 Research Paper Competition

ACHIEVING EXCELLENCE IN A CHANGING ACQUISITION ENVIRONMENT

Acquisition Leadership:
An Opportunity Lost for Acquisition Excellence?
Michael J. Kotzian

The Product Support Manager:
Achieving Success in Executing Life Cycle Management Responsibilities
Bill Kobren

How Well Are PMs Doing?
Industry View of Defense Program Manager Counterparts
Roy L. Wood

DAU Defense Acquisition University

Report Documentation Page

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Unless program managers (PM) tackle cost containment head-on, future weapon system acquisition successes may be jeopardized, resulting in fewer products and services to equip the nation's warfighters. The United States can ill afford any decrease in its preparedness when the nation is currently waging war on two fronts. This research examines cost containment in the context of Total Life Cycle Cost Management. A more thorough understanding and aggressive application of cost-containment strategies could conceivably shift acquisition outcomes to a more cost-effective posture. Responding to a survey conducted as part of this research, 887 Department of Defense (DoD) acquisition professionals provided input on cost containment, including tool types and associated processes. Of those 887 respondents, 543 were current or former DoD PMs.

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Department of Defense Acquisition Test and Evaluation (T&E) has remained the gatekeeper to Major Defense Acquisition Program production since its formalization over 25 years ago. Under T&E's oversight, the types, methods, and sources for warfighting systems have significantly evolved to meet/counter the nation's security challenges. The DoD has studied and recommended actions to accelerate Acquisition Reform for decades, while only

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"tweaking at the margins" for T&E. Now is the time for DoD to consider a new approach to T&E, steering away from the "buy" decision to the more relevant "acceptance" and "operational" domains. This article outlines the issues and proposes a new "Alpha-Omega" map for T&E that charts the way ahead for how DoD actually procures its weapon systems.

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The Department of Defense recently mandated the incorporation of Human Systems Integration (HSI) early in the acquisition cycle to improve system performance and reduce ownership cost. However, little documentation of successful examples of HSI within the context of systems engineering exists, making it difficult for the acquisition community to disseminate and apply best practices. This article presents a case study of a large Air Force project that represents a successful application of HSI. The authors explore the influence of both the Air Force and the project contractor. Additionally, they identify top-level leadership support for integrating HSI into systems engineering processes as key to HSI success, reinforcing the importance of treating HSI as an integral part of pre-Milestone A activities.

Remarks
FROM THE EXECUTIVE EDITOR

Welcome to this very special commemorative issue of the *Defense Acquisition Review Journal (ARJ)*. In 2008, the Defense Acquisition University Alumni Association (DAUAA), along with the DAU Research Department, initiated the annual DAUAA 2010 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. In 2010, the DAUAA Research Paper Competition was completed for the third consecutive year, and winners will be recognized at the DAU Acquisition Community Symposium on April 13, 2010. The theme for research papers in the 2010 competition is "Achieving Excellence in a Changing Acquisition Environment." The top three papers will receive the Hirsch Award and cash prizes of $1,000, $500, and $250 respectively. A panel of subject matter experts reviewed all submitted research papers and selected the top three winners. This research paper competition results from a special relationship between the DAUAA, the DAU Research Department, and the *ARJ*.

I am extremely pleased and proud to publish the three winning papers for the third annual DAUAA 2010 Research Paper Competition in this issue of the *ARJ*, along with four other outstanding papers that were nominated for awards. The theme for the 2010 competition was very broad, and you will see many diverse topics in this issue. A total of seven papers was selected for publication in this issue.

The first place winning research paper for the DAUAA 2010 Research Paper Competition is "Acquisition Leadership: An Opportunity Lost for Acquisition Excellence?" by Michael J. Kotzian. Many scholars believe that leadership is one of the most important factors—if not *the* most important—that an organization must possess to be successful in today's global environment. The defense acquisition management system has continued to be questioned in terms of delivering cost-effective and timely complex weapons systems that meet warfighter requirements. As a means to improve this ongoing dilemma, this paper posits that increased attention across the acquisition community should be paid, not to improved processes and procedures, but to leadership. The importance of leadership competency is reviewed from the perspective of the Service's Professional Military Education institutions. As the organization responsible for training the acquisition, technology, and logistics workforce on the complexities of the defense acquisition management system, the DAU is called upon to

improve its entry and mid-level course offerings associated with acquisition by providing meaningful instruction regarding foundations of leadership competency.

The second place winning paper is "The Product Support Manager: Achieving Success in Executing Life Cycle Management Responsibilities," by Bill Kobren. In October 2009, President Obama signed the Fiscal Year 2010 National Defense Authorization Act (Public Law 111-84). The legislation contained a provision in Section 805 entitled, "Life Cycle Management and Product Support," requiring: (1) the Secretary of Defense to issue comprehensive guidance on life-cycle management, and the development and implementation of product support strategies for major weapon systems; (2) that each major weapon system be supported by a product support manager (PSM); and (3) that each PSM position be performed by a properly qualified member of the armed forces or full-time employee of the Department of Defense. The research paper examined the intent, importance, and implications of this provision, and offered recommendations for implementation by the Office of the Deputy Under Secretary of Defense for Logistics & Materiel Readiness, which drafts DoD policy to implement this new statutory requirement.

The third place winning paper is "How Well Are PMs Doing? Industry View of Defense Program Manager Counterparts," by Roy L. Wood. Large, complex defense acquisition programs have been plagued by cost overruns, delayed schedules, and subpar performance. Much of the responsibility has been attributed to weaknesses in competencies of government program managers (PM). This article, based on the author's doctoral dissertation, provides a new perspective on government PM competencies by surveying 146 defense industry managers who work with the government PMs. These industry managers rated the importance of common PM competencies and assessed how well, from their perspective, their government counterparts met those competencies. The data gathered from this survey revealed several insights, including a conclusion that government PM performance on several key technical skills may need improvement. The results of this study will be useful in assessing training and development strategies for government PMs.

Four additional research papers were nominated for publication in this commemorative issue. The next paper is "Improving Defense Acquisition Decision Making" by COL William R. Fast, USA (Ret.). This research investigates evidence and tests the hypothesis that the linkages between the defense acquisition management system,

the requirements process, and the budgeting system are not sufficiently defined to enable the success of acquisition programs. These disconnects contribute to weapon system cost overruns, schedule delays, and performance problems, and are exacerbated by the ever-changing global security environment and rapid pace of technological advancement. Through historical research, qualitative and quantitative analyses, and a comprehensive review of current policies and procedures, this research illuminates these areas of disconnect and proposes specific recommendations to fix them.

The fifth research paper selected for publication is "It's Time to Take the Chill Out of Cost Containment and Re-Energize a Key Acquisition Practice," by Col Robert L. Tremaine, USAF (Ret.) and Donna J. Seligman. Little will change regarding the prospect of future weapons systems acquisition successes unless PMs continue to tackle their programmatic major hurdles head-on, but one more than others—cost containment. Otherwise, the DoD might have fewer products and fewer services to offer its warfighters. The United States can ill afford any decrease in its preparedness when the nation is currently waging war on two fronts. To better understand some of the obstacles, the authors examined cost containment in the context of Total Life Cycle Cost Management. They believe a more thorough understanding and aggressive application of cost-containment strategies could conceivably shift acquisition outcomes to a more cost-effective posture. Responding to a survey conducted as part of this research, 887 DoD acquisition professionals provided input on cost containment, including tool types and associated processes.

The sixth research paper in this issue is "A New Alpha-Omega Map for Acquisition Test and Evaluation," by George Axiotis. Department of Defense Acquisition Test and Evaluation (T&E) has been the gatekeeper to Major Defense Acquisition Program production since its formalization over 25 years ago. Yet, the landscape of the types, methods, and sources for warfighting systems has significantly evolved. The department has studied and recommended action for Acquisition Reform for decades, while only "tweaking in the margins" for T&E. The time is right for DoD to consider a new approach to T&E, steering away from the "buy" decision to the more relevant "acceptance" and "operational" domains. This paper outlines the issues and proposes a new "Alpha-Omega" map for T&E for the way we actually procure DoD systems.

The final research paper in this special issue is "The F119 Engine: A Success Story of Human Systems Integration in Acquisition," by 2ndLt

Kevin K. Liu, USMC, Ricardo Valerdi, Donna H. Rhodes, Col Larry Kimm, USAF, and Lt Col Alvis Headen, USAF. The Department of Defense recently mandated the incorporation of Human Systems Integration (HSI) early in the acquisition cycle to improve system performance and reduce ownership cost. However, little documentation exists of successful examples of HSI within the context of systems engineering, making it difficult for the acquisition community to disseminate and apply best practices. This paper presents a case study of a large Air Force project that represents a successful application of HSI. The authors explore the influence of both the Air Force and the project contractor. Top-level leadership support is identified for integrating HSI into systems engineering processes as key to HSI success, reinforcing the importance of treating HSI as an integral part of pre-Milestone A activities.

And now, please allow me a few parting thoughts ... I will be moving to a new position soon, and Dr. Larrie D. Ferreiro will be taking over as the Executive Editor of the *ARJ*. It has been a true pleasure to be associated with some of the finest acquisition professionals from all walks of the DoD and defense industry, and to be able to share thoughts and philosophies with you. My tenure as Executive Editor of the *ARJ* began in August 2005; since then, the DAU Press has worked with me to bring you 15 issues. Between teaching, consulting, managing individual research projects, and overseeing the DAU Research Enterprise, I was always challenged to find the time and inspiration to publish a fresh, quality product ... and I certainly didn't do it alone! I have benefitted greatly from the knowledge and professional judgment of many folks at DAU, and I'd like to mention three of them specifically by name: Norene Fagan-Blanch, managing editor; Collie Johnson, technical editor; and Ed Boyd, Director of DAU Visual Arts & Press. Without their dedication, help, and advice, I would not have lasted this long. Dr. Ferreiro will be taking over as Executive Editor starting with the next issue (No. 55). Like me, Larrie comes from the Naval side of the DoD, but 5 years at DAU have given him a "purple" outlook. Please continue for Larrie the excellent support and flow of articles that I have enjoyed from many of you over the past 5 years.

Dr. Paul Alfieri
Executive Editor
Defense ARJ

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ACQUISITION LEADERSHIP: AN OPPORTUNITY LOST FOR ACQUISITION EXCELLENCE?

Michael J. Kotzian

The Defense Acquisition Management System (DAMS) has continued to be questioned in terms of delivering cost-effective and timely complex weapon systems that meet warfighter requirements. As a means to improve this ongoing dilemma, this article posits that increased attention across the acquisition community should be paid, not to improved processes and procedures, but to leadership. The importance of leadership competency is reviewed from the perspective of the Services' Professional Military Education institutions. As the organization responsible for training the Acquisition, Technology, and Logistics Workforce on the complexities of the DAMS, the Defense Acquisition University is called upon to improve its entry- and mid-level course offerings associated with acquisition by providing meaningful instruction regarding foundations of leadership competency.

Keywords: *Transformational Leadership; Transactional Leadership; Organizational Success; Defense Acquisition Management System (DAMS); Culture; Professional Military Education (PME); Acquisition, Technology, and Logistics (AT&L) Workforce*

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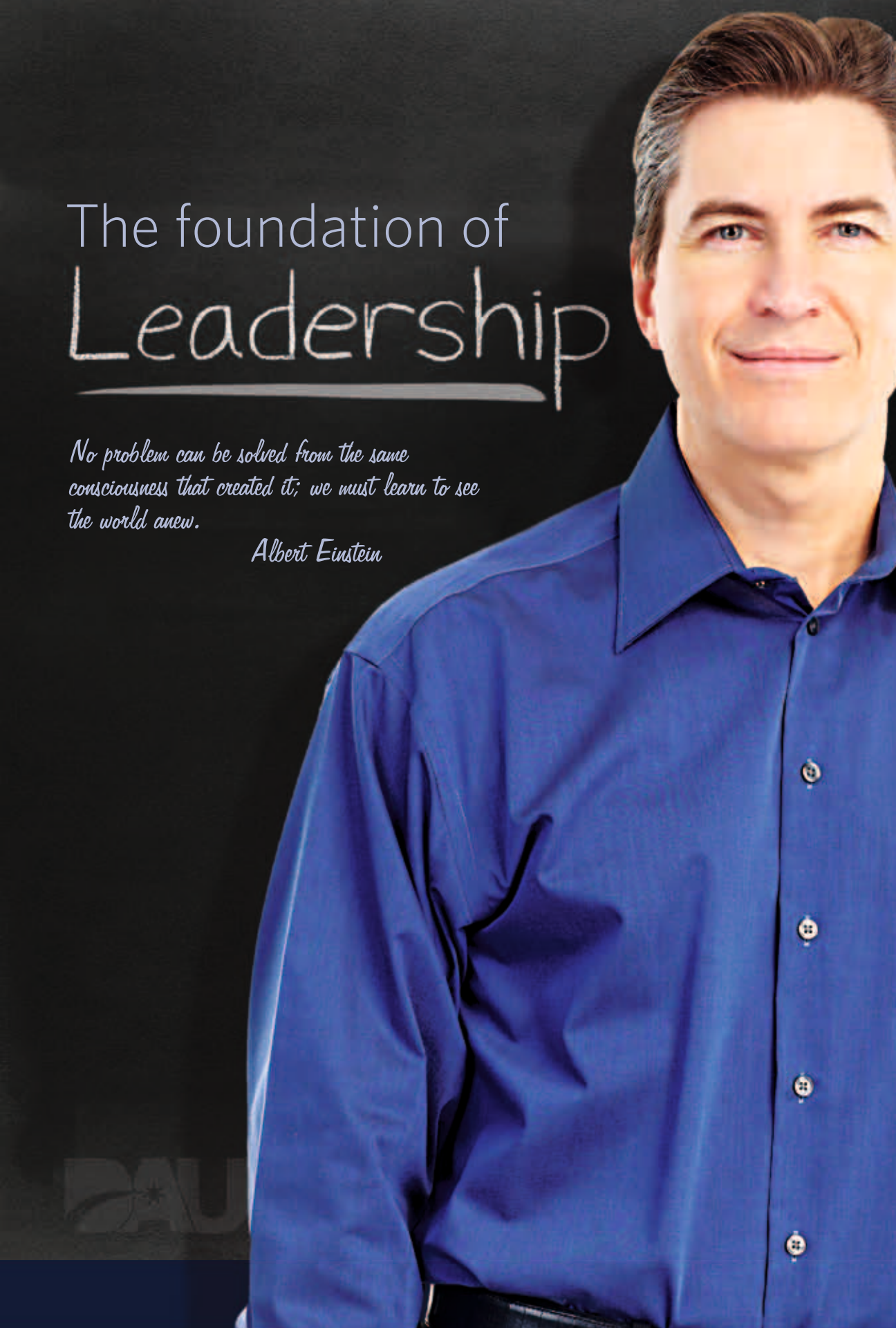

The foundation of
Leadership
No problem can be solved from the same consciousness that created it; we must learn to see the world anew.
Albert Einstein

The general consensus of the Department of Defense (DoD) community of acquisition practitioners appears to indicate that the weapons systems acquisition process is broken and needs to change.

In March 2009, the U.S. Government Accountability Office (GAO) issued its most recent annual assessment of DoD Major Defense Acquisition Programs (MDAPs) for 2008 by concluding that, of the 96 MDAPs assessed, "total research and development costs are now 42 percent higher than originally estimated, and the average delay in delivering initial capabilities is now 22 months. In addition, 42 percent of the programs reported a 25 percent or more increase in acquisition unit costs" (GAO, 2009, p. 6). Shortly thereafter, Secretary of Defense Robert Gates held a news conference in April 2009 where he announced major changes to the fiscal year 2010 defense budget, stating DoD needed to "reform how and what we buy; meaning a fundamental overhaul of our approach to procurement, acquisition, and contracting" (DefenseLink, 2009). This was quickly followed by a June 2009 editorial from Deputy Secretary of Defense William Lynn III who wrote, "For the first time in decades, the political and economic stars are aligned for a fundamental overhaul to the way the Pentagon does business" (Lynn, 2009). Most recently, in July 2009 the Business Executives for National Security (BENS) Task Force issued a report that identified end-to-end problems with the acquisition system, including "requirements creep, funding instability, poor cost estimating, immature technology, and the lack of flexibility to solve problems. These are compounded by the fact that many individuals with little or no accountability can profoundly impact funding, schedule, personnel assignments, and administrative demands" (BENS, 2009, p. 6).

So what's to be done to ensure that the warfighter receives the most capable weapons systems that meet the requirements, while being delivered on time and at the estimated cost? Regrettably, the vast majority of acquisition reform approaches will focus on adjustments to the processes and procedures that guide the DAMS. As an example, when the guiding document governing the *Defense Acquisition Management System (DAMS)*—DoD Instruction 5000.02, *Operation of the Defense Acquisition System*—was recently updated and released in December 2008 after months of anticipation, the result was a 110 percent increase in content from the previous version (Brown, 2009). This was accompanied by an increase in regulatory and statutory documentation requirements in support of all major milestone events.

The alteration of such a foundational policy should be viewed as an organizational change. From a DoD perspective, the introduction of increasingly complex and altering business policies and procedures can only be viewed as a change that impacts those who are charged with implementing such policy and procedures through enactment of the DAMS—members of the *Acquisition, Technology, and Logistics (AT&L) Workforce*.

According to Linstone and Mitroff (1994), three factors merit consideration when implementing change: technical, organizational, and personal perspectives. Research dealing with organizational change unfortunately "has mainly focused on organizational factors" while "neglecting the person-oriented issues" (Vakola, Tsausis, & Nikolaou, 2004, p. 88). While people are the most important factor in implementing change, they also represent the most difficult factor with which to effect change (Linstone & Mitroff, 1994). For any organizational change to be effective, challenging the beliefs, assumptions, and attitudes of the workforce is critical, as the most influential leverage point for meaningful change resides within the human system (Juechter, Caroline, & Alford, 1998).

Why is there resistance to change?

Any substantive change to organizational processes will be viewed by some personnel as upsetting and by others as cataclysmic, which can lead to workforce resistance in accepting the change. Why is there resistance to change? A growing body of academic literature suggests "organizational change places demands not only on the organization, but also on the individual employees, both physically and psychologically" (Cole, Harris, & Bernerth, 2006, p. 353). Employees are now being asked to adapt to change without disruption; however, resistance to change is the more common reaction (Caldwell, Herold, & Fedor, 2004). Resistance occurs because it threatens the status quo (Beer, 1980; Hannan & Freeman, 1984; Spector, 1989) or increases fear and the anxiety of real or imagined consequences (Morris & Raben, 1995; Smith & Berg, 1987), including confidence in the ability to perform (Morris & Raben, 1995; O'Toole, 1995).

In a previous *Defense Acquisition Review Journal* article, the author posited that leadership and *culture* were critical factors when it came to the retention of DoD's AT&L Workforce (Kotzian, 2009). This article will continue one of the threads associated with the author's earlier article in terms of pursuing acquisition excellence: The importance of leadership—posited as the key attribute required within DoD's acquisition community—is paramount if the AT&L Workforce is going to overcome the resistance to policy change and begin to approach, in some appreciable measure, the expectations of taxpayers, the Congress, and most importantly, warfighters. Succinctly, the production of effective weapons systems delivered in a timely manner at a reasonable cost will constitute acquisition excellence and all it embodies.

Purpose

Many scholars believe that leadership is one of the most important factors—if not *the* most important—that an organization must possess in order to be successful in today's global environment. Unfortunately, most of the readings about organizations over the last half-century have focused on management. The management techniques to be used in the 21st century are expected to be very similar to those used by management in the 20th century. In fact, "similar management problems have existed as long as human societies have existed" (Hofstede, 1999, p. 35). The problem is that this process has succeeded in developing "generations of executives who know much more about management than they do about leadership" (Kotter, 1998, p. 5). In the absence of effective leadership, "the probability that a firm can achieve superior or even satisfactory performance when confronting the challenges of the global economy will be greatly reduced" (Hitt & Ireland, 1999, p. 43). Clearly, a current and future imperative for DoD is to produce as many workforce members as possible who know something about leadership because "people who are just managers will never produce the cultures necessary to adapt to a rapidly changing 21st century" (Kotter, 1998, p. 5). The clear observation is that organizations "will rise and fall based on the quality of their leadership," and this will be more true in the 21st century as organizations "struggle with their missions, identities, and strategies" (Zahra, 1999, pp. 39–40).

When it comes to *organizational success*, the academic literature is repetitive and unequivocal in its advocacy of leadership as a key factor. Definitions of leadership abound as do academicians who have studied leadership, but the typical gist is that leadership "involves a process whereby intentional influence is exerted by one person over other people to guide, structure, and facilitate activities and relationships in a group or organization" (Yukl, 1998, p. 3).

Through the years, many different leadership styles have been put forth and studied, e.g., Total Quality Management or TQM, which emerged as the dominant management style during the 1980s through 1990s. The scientific study of leadership can be roughly divided into three periods: (1) trait theory, a premise that presupposes leaders are somehow different from those who remain followers; (2) behavior theory, which tries to search out behavioral characteristics of supposed great leaders and subsequently identifies three styles on a continuum from autocratic to democratic to laissez-faire; and (3) contingency theory, which suggests that the success of any leader depends upon applying the proper methodologies based on the situation (Chemers, 1995). However, within recent academic literature, one of the more common themes associated with organizational success is that of *transformational leadership* in lieu of *transactional leadership* (Herold, Fedor, Caldwell, & Liu, 2008; Randall & Coakley, 2006). Transactional leadership relies on a contractual exchange of rewards for efforts dependent on positive and

negative reinforcement (Bass, 1990). The follower complies with the leader's requests for the rewards but is not necessarily committed to the leader or organization (Metscher, 2005). A common view of transactional leadership is that of the stereotypical manager who simply tasks the followers and monitors progress to ensure the tasks are correctly accomplished.

The alternative leadership style seemingly better suited to accomplish organizational success is transformational leadership characterized by an "appeal to followers' sense of values … [and enables them] to see a higher vision and [encourages] them to exert themselves in the service of achieving that vision" (Herold et al., 2008, p. 347). This type of leadership style relies more on personal characteristics such as charisma, interpersonal skills, high levels of communication, and characteristics other than rank or structure. Transformational leaders are considered change agents (Metscher, 2005) and, contrary to transactional leaders, are more closely associated with the term "leader" vice manager.

If leadership is viewed as such an important factor in organizational success, why would an organization fail to ensure that its workforce receives as much leadership training as early as possible?

While there is almost universal agreement that leadership is a critical factor to the success of any organization—such as enacting major policy change like the new DoD Instruction 5000.02—the question remains as to whether leadership is part of an individual's inherent ability, or a trait that can be learned, or both. The intent of this article is not to prove any of these three perspectives. Rather, this article examines the connection between leadership and education. If leadership is viewed as such an important factor in organizational success, why would an organization fail to ensure that its workforce receives as much leadership training as early as possible? Education is seen as a "critical component of managing and adapting to change in any organization and any area of endeavor" (Kenney, 1996, p. 52).

Within DoD, Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 1800.01D, *Officer Professional Military Education Policy (OPMEP)*, outlines "the policies and procedures necessary to fulfill PME [Professional Military Education] responsibilities" (CJCS, 2009, p. 2). This CJCSI provides the framework for development of Service and Joint officers by organizing the PME continuum into five military educational levels: precommissioning, primary, intermediate, senior, and general/flag officer. It defines the focus of each educational level in terms of the major levels of war (tactical, operational,

and strategic) and links the educational levels so each builds upon the knowledge and values gained in previous levels (CJCS, 2009, p. A-A-1).

In addition, the CJSCI framework also recognizes both the distinctiveness and interdependence of Joint and Service schools in officer education. Service schools, in keeping with their role of developing Service specialists, place emphasis on education primarily from a Service perspective in accordance with joint learning areas and objectives (CJCS, 2009, p. A-A-1).

Leadership training is conducted through the PME institutions of each individual Service (Air Force, Army, Navy, and Marine Corps), where future leaders "spend their formative years in a single Service culture that shapes their attitudes, values, and beliefs about what constitutes 'good' and 'bad' leadership styles" (English, 2002, p. 2). Such training is ultimately focused on mission accomplishment in terms of conducting successful combat operations. The crucial role for PME is to "help future officers understand how the world is changing and to enable them to determine how the military must change to fit this new world" (Kenney, 1996, p. 53). The PME system, according to Kenney, is uniquely suited to the vital task of preparing future military leaders not simply to operate, but to thrive in such an environment, to adapt to rapidly changing conditions, and to reorient their thoughts and actions in real time to contingencies that may not be what they seem (Kenney, 1996, p. 53).

Alternatively, the mission for educating DoD's AT&L Workforce—those members responsible for enacting the DAMS—primarily falls to the Defense Acquisition University (DAU). This responsibility is embedded in DAU's mission statement: "Provide practitioner training, career management, and services to enable the acquisition, technology, and logistics (AT&L) community to make smart business decisions and deliver timely and affordable capabilities to the warfighter" (DAU, 2008, p. 1). DAU will perform this practitioner training through one or more pillars comprising the AT&L Performance Learning Model (PLM): training, continuous learning, mission assistance, and knowledge sharing (DAU, n.d.).

In terms of training the AT&L Workforce, it can be argued that all PLM pillars provide opportunities to enhance learning about the DAMS. For example, DAU supported awareness about the revised DoD Instruction 5000.02 through rapid-deployment events where DAU went directly to their customer base to foster an understanding of the changes and impacts associated with the new policy guidance. However, most of DAU's mission interface with the AT&L Workforce in terms of sheer numbers is accomplished through DAU training courses offered in response to enactment of the Defense Acquisition Workforce Improvement Act (DAWIA), which was initially signed into law in 1990.

DAWIA identifies—by career field and certification level—the education, training, and experience requirements DoD AT&L Workforce members must achieve to progress over time within DoD (DAU, 2008). DAU identifies

the type of assignment, core certification standards, and unique training positions required by AT&L Workforce members for each of 15 different career fields leading to Level I, Level II, and Level III certification. In addition, "core plus" development guidance is provided for those AT&L Workforce members seeking additional guidance/knowledge beyond the level certification standards (DAU, 2010).

As alluded to at the start of this article, the remarks from DoD's senior leadership and recent independent studies signify that DoD is undergoing a significant change in corporate worldview as the organization transitions from an industrial-age military to an information technology-age military, where the most important changes are projected to be organizational and doctrinal (Davis, Gompert, Hillestad, & Johnson, 1998). As a systematically entrenched organization, fundamental changes in the DoD's structure—indeed, the organization's very way of "doing business"—will prove a daunting task.

The rationale for the research undertaken is that, by any standard, DoD is truly a world-wide enterprise spending billions of dollars on the procurement of major weapons systems intended to support the warfighter. To accomplish this task in a cost-effective and timely manner, DoD needs to ensure that all AT&L Workforce members responsible for transition are properly prepared to do so. This article posits that one of the critical attributes all AT&L Workforce members need—to carry out this tasking—is continued training, incorporating the concept of leadership. Further, such leadership training should be offered as early as possible to members of the AT&L Workforce who are seeking DAWIA career field certification through DAU.

Therefore, the purpose of this research article is to examine the following research question: As the DoD organization responsible for educating the AT&L Workforce on the DAMS, is DAU missing an opportunity to provide leadership training at the entry- and mid-levels to the AT&L Workforce?

Method

This article's research question involves the importance of leadership training as part of an AT&L Workforce member's course of study undertaken during DAWIA certification. To address this question, this article relies upon a mix of quantitative and qualitative research methodologies based on the notion that "qualitative and quantitative methods should be viewed as complementary rather than rival camps" (Jick, 1979, p. 602).

QUANTITATIVE METHODOLOGY

From a quantitative perspective, this article references survey data that were collected in 2008 as part of a study regarding organizational change and subcultures (Kotzian, 2009). The survey population was military and civilian senior leaders, managers, or professionals associated with the DoD—not limited to the AT&L Workforce but thought to be a representative cross-section, applicable in general to the AT&L Workforce. Senior leadership (executive-level) membership was defined as rank structure O-6 and above for military members, and GS-15 (or equivalent) and above for civilian members. Mid-level manager (mid-level) membership was defined as rank structure O-4 and O-5 for military members, and GS-14 and GS-13 (or equivalent) for the civilian members. Professional (entry-level) membership was defined as rank structure O-1 through O-3 and noncommissioned officers for military members, and GS-11 and GS-12 for civilian members.

The survey's sampling frame was comprised of individuals attending one of DoD's PME academic institutions, which was meant to provide a representative cross-section of the three population hierarchies (i.e., senior leaders, management, and professional) from which DoD identifies future leaders, managers, and professionals.

The chosen survey instrument was the Organizational Culture Assessment Instrument (OCAI), which is based on the Competing Values Framework (CVF). The CVF was developed by Quinn and Rohrbaugh (1983), which graphically categorized organizational effectiveness into four quadrants, separately labeled to distinguish its most notable characteristics—clan, adhocracy, market, and hierarchy. The clan culture is named because of its similarity to a family-type organization. The adhocracy culture places a great deal of emphasis on flexibility and external focus. The market culture refers to the type of organization that is mainly focused on external constituencies such as suppliers, customers, contractors, regulators, etc. The hierarchy culture can be viewed as the traditional bureaucracy (Quinn & Rohrbaugh, 1983).

The survey instrument has been academically reviewed and proven for reliability and validity. A pretest of the survey was conducted with some faculty and students at a prominent PME academic institution. Slight word changes were made to some of the survey questions based on pre-test feedback to make the survey more DoD-centric. The formal survey instrument was distributed via electronic mail.

The OCAI uses a response scale in which respondents divide 100 possible points among four options across six initial questions. The compilation of A options correlates to the clan culture; the compilation of B options correlates to the adhocracy culture; the compilation of C options correlates to the market culture; and the compilation of D options correlates to the hierarchy culture (Cameron & Quinn, 1999). The summation of points within each quadrant is then plotted to form a four-sided profile

that graphically illustrates the strength of each culture. Respondents answer the six questions two times: initially to provide responses regarding how respondents perceive the organization as it currently is (now) and followed by responses as to how they would like to see the organization in 5 years (preferred). The applicability of the survey to this research article is that one of the questions specifically deals with the topic of leadership.

QUALITATIVE METHODOLOGY

Attempting to interpret the actions of humans is very much a nonlinear endeavor. Qualitative research is best used to understand the complexities associated with social phenomena (Tucker, Powell, & Meyer, 1995) as it ensures "a commitment to seeing the social world from the point of view of the actor" (Bryman, 1984, p. 77).

As part of the OCAI survey, an open-ended question was placed at the end of the survey tool. Any qualitative responses were completely voluntary on the part of each respondent and could address any aspect that the respondent wished to discuss.

Open-ended questions allow researchers to obtain answers that are unanticipated, may better describe the real views of the respondents, and allow for a response that is phrased in the respondent's own words (Fowler, 2002). While self-administered open-ended questions may not be comparable across all respondents, the responses can be evaluated for patterns that may repeat over many different respondents to make generalized observations (Salkind, 2003).

In addition, documentation was reviewed for applicability in support of this article's research question. Somewhat similar to a literature review, this methodology consists of reviewing documentation "composed and released either internally or for public consumption" as well as a means to "confirm or contradict information gathered through other means" (Salkind, 2003, p. 208).

Results

The results associated with this article consist of four sets. Quantitative results are provided from responses received from the 2008 OCAI survey study. Qualitative results are provided from documentation reviews associated with Service PME curriculum, DAU DAWIA curriculum, and open-ended responses from the 2008 OCAI survey study. All OCAI survey results referenced as part of this article are related to survey questions associated with the survey's leadership dimension.

QUANTITATIVE ANALYSIS

From a quantitative perspective, a total of 1,284 usable OCAI survey results was captured. The OCAI survey results in terms of cultural values (clan, adhocracy, market, hierarchy) provided a comparison between the overall military and civilian culture quadrants in terms of leadership and are summarized in Figures 1, 2, and 3. Figure 1 provides a four-sided plot of the overall military sample population mean averages in terms of perceived importance of the leadership dimension. Figure 2 provides a four-sided plot of the overall civilian sample population mean averages in terms of perceived importance of the leadership dimension. Figure 3 provides a comparison overlay of Figures 1 and 2 to illustrate commonalities and differences between the overall military and civilian sample populations in terms of perceived importance of the leadership dimension.

In terms of the "now" organizational profile data for the leadership dimension, both the military and civilian sample populations view the market leadership style as dominant (mean averages of 28.5 and 27.7, respectively). In addition, both the military and civilian sample populations view the remaining leadership styles in the same order: hierarchy leadership style (25.2 and 26.0, respectively), followed by the clan leadership style (25.1 and 24.1, respectively), and concluding with the adhocracy leadership style (21.2 and 22.3, respectively).

FIGURE 1. CULTURE PROFILE OF THE OVERALL MILITARY SAMPLE POPULATION

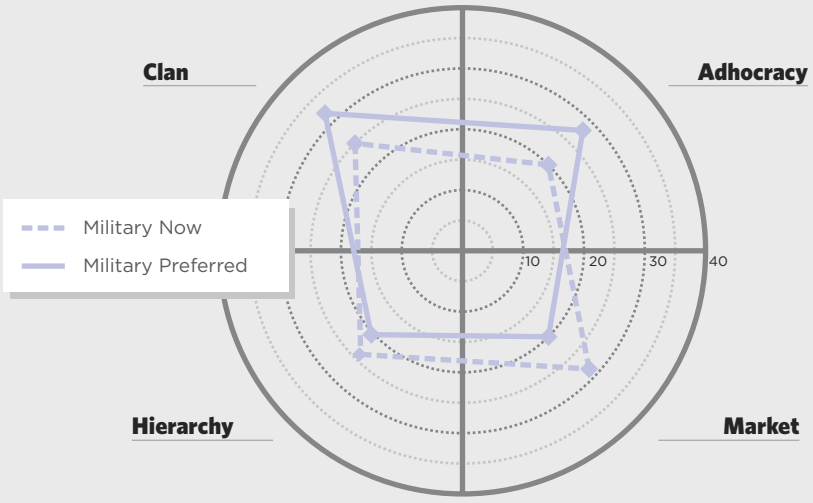


FIGURE 2. CULTURE PROFILE OF THE OVERALL CIVILIAN SAMPLE POPULATION

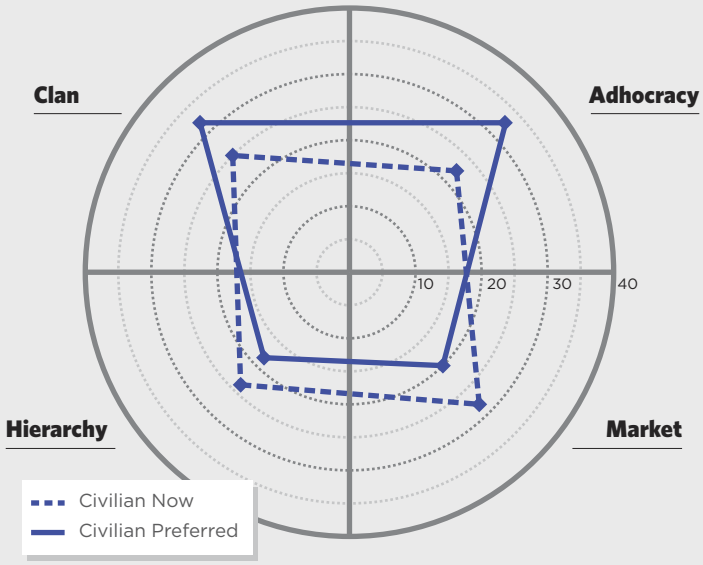
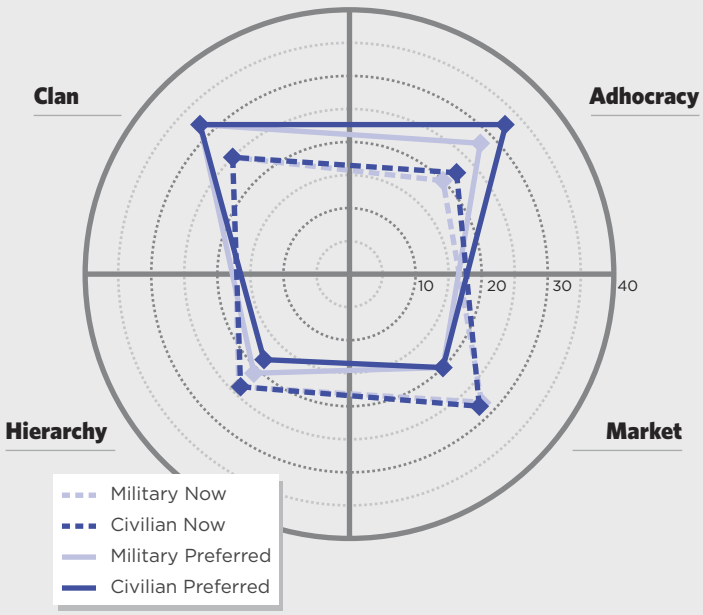


FIGURE 3. OVERLAY OF CULTURE PROFILES—OVERALL MILITARY SAMPLE POPULATIONS



In terms of the "preferred" organizational profile for the leadership dimension, both the military and civilian sample populations view the clan leadership style as dominant (32.7 and 32.4, respectively). In addition, both the military and civilian sample populations view the adhocracy leadership style as the next most desirable (27.3 and 31.1, respectively). The military sample population concludes with the hierarchy (20.4) and market (19.6) leadership styles, respectively. Meanwhile, the civilian sample population reverses that order by preferring the market (19.1) and then hierarchy (17.3) leadership styles, respectively.

QUANTITATIVE ANALYSIS

To evaluate the role of leadership within the Service PME curriculum, a thorough analysis of available documentation was undertaken. The importance of leadership in the early stages of Service PME curriculum has been a common theme from the historical beginnings of PME. As identified by Holder and Murray (1998), leadership was annotated as a primary focus area of education for the entry-level military officers (p. 85). Figure 4 provides an overview chart of the latest Service PME guidelines (CJCS, 2009, p. A-A-A-1). According to this document, the Chairman's PME vision "entails ensuring that officers are properly prepared for their leadership roles at every level of activity and employment, and through this, ensure that the U.S. Armed Forces remain capable of defeating today's threat and tomorrow's" (CJCS, 2009, p. 1). As early as the precommissioning education level, leadership is one of the foundational focus areas (CJCS, 2009, p. A-A-3).

Leadership development is prevalent within all of the Service PME institutions, which rely on similar "frameworks" used to advocate the importance of leadership. The Navy relies upon their Leadership Competency Model (Department of the Navy, n.d.). The Marine Corps promotes 14 leadership traits (U.S. Marine Corps, n.d.). The Air Force uses Air Force Doctrine Document 1-1 to define three leadership competencies from the tactical through strategic levels (Department of the Air Force, 2006). Similar to the Air Force and Navy, the Army represents leadership at the direct, organizational, and strategic levels with an exhaustive list of competencies (Department of the Army, 2006). The key to all of these frameworks is that leadership is a common thread that appears early within all Service PME institutions.

In addition, each of the Service PME institutions has a department or dedicated course focused on leadership development and training: the Air War College has the Department of Leadership and Ethics (Air War College, n.d.); the Army War College has the Department of Command, Leadership, and Management (Army War College, n.d.); the Naval War College has the College of Operational and Strategic Leadership (U.S. Naval War College, n.d.); and the Marine Corps has dedicated leadership courses as part of its

FIGURE 4. SERVICE OFFICER PME CONTINUUM

Grade Education Level	**Cadet/Midshipman** Precommissioning	**0-1/0-2/0-3** Primary	**0-4** Intermediate
Educational institutions and courses	Service Academies ROTC OCS/OTS	• Branch, Warfare, or Staff Specialty Schools • Primary-Level PME Courses	• Air Comma Staff Colleg • Army Comm General Sta • College of I Command a • Marine Cor Command a College • JFSC; Joint and Combi Warfighting AJPME
Levels of war emphasized	Conceptual Awareness of all Levels		
			Tactical
Focus of military education	Introduction to Services' Missions	• Assigned Branch, Warfare, or Staff Specialty	• Warfighting the context Operationa • Intro to the strategy an security str • Develop an capabilities creative tho

Note. AJPME=Advanced Joint Professional Military Education (Army); ICAF=Industrial College of the Armed Fo
OTS=Officer Training School; ROTC=Reserve Officer Training Corps; SJIOAC=Senior Joint Information Operatio

	0-5/0-6 Senior	0-7/0-8/0-9 General/Flag
e		
nd and ge mand and ff School Naval and Staff ps and Staff ned g School;	• Air War College • Army War College • College of Naval Warfare • Marine Corps War College • Industrial College of the Armed Forces • National War College • JFSC; Joint and Combined Warfighting School, AJPME • JFSC, Joint Advanced Warfighting School	• CAPSTONE • Joint Functional Component Commander Courses • SJIOAC • Joint Flag Officer Warfighting Course • PINNACLE
	Strategic	
	Operational	
g within t of l Art ater d national ategy alytical s and ought	• Service Schools: strategic leadership, national military strategy, and theater strategy • NWC: national security strategy • ICAF: national security strategy, with emphasis on the resource components	• Joint matters and national security • Interagency process • Multinational operations

orces; JFSC=Joint Forces Staff College; NWC=Naval War College; OCS=Officer Candidate School;
ns Applications Course

Command and Staff College and Marine Corps War College (U.S. Marine Corps, n.d.). As a result, the curriculum for each of these Service PME institutions covers aspects of leadership as a focus area for all students starting at the beginning of any formal Service PME.

Also, as referenced earlier, DoD has an overarching policy governing officer PME intended to identify the "policies, procedures, objectives, and responsibilities for officer *professional military education (PME)* and joint officer professional military education (JPME)" (CJCS, 2009, p. 1). Leadership is prevalent throughout this overarching guidance document from which all Service PME flows.

From the DAWIA perspective, DAU offers acquisition-related training for DoD's AT&L Workforce. As of 2008, DAU graduated 154,252 students: 118,391 via Web-based training and 35,861 via resident (face-to-face) training—a 300 percent increase since fiscal year 1999 (DAU, 2008, p. 9). For those classes required for AT&L Workforce member Level I, Level II, and Level III certification, 100-level, 200-level, 300-level, and 400-level classes are separated.

DAU's 2010 catalog lists a total of 95 classes available to the AT&L Workforce in support of acquisition-related certification. Of these classes, only one alludes to leadership: ACQ 450, Leading in the Acquisition Environment. The ACQ 450 course description describes the class as an "action-based learning course" that "provides an overview of the competencies and skills needed to lead in an acquisition environment" (DAU, 2010). Targeted attendees for this class consist of civilians categorized in terms of this article as the mid-level (GS-13 and up) and executive-level (O-5 and above) positions. However, Level III certification is also identified as a course prerequisite, which virtually guarantees that only the most experienced AT&L Workforce members will actually attend this class.

DAU also offers tailored 400-level classes for executive-level AT&L Workforce members, primarily personnel assuming the program manager role and associated responsibilities for a major weapon system program. However, these 400-level classes are structured as "modules" covering various topics of interest to any prospective program manager: earned value management, risk management, acquisition policy and strategy, test and evaluation, contract management, financial management, etc. Ten 400-level courses are offered, but only two have a module with "leadership" in the title: The Executive Program Manager's Course (EPMC) course (PMT 402) has a module "Leading Change"; and the Executive Refresher Course (ACQ 405) has a module "Leadership and Management Projects."

DAU's most popular course across the enterprise, particularly with entry-level AT&L Workforce members, is ACQ 201, Intermediate Systems Acquisition, with an annual enrollment of about 8,000 students (DAU, 2008). In this course, which includes week-long face-to-face class facilitation, only one slide is dedicated to the topic of leadership. In addition, the leadership styles referenced as part of this one-slide teaching tool refer to leadership

styles that most academicians would not typically find in a teaching environment. As with the majority of DAU's course material intended for AT&L Workforce student instruction, the specific DAU instructor/facilitator determines the level of emphasis on the concept of leadership and/or the level of in-depth discussion regarding the topic of leadership. Otherwise, the ACQ 201 AT&L Workforce student will typically be exposed to no more than 10 minutes of discussion "dedicated" to leadership.

Whether a qualitative comment was positive or negative, the message expressed by many survey respondents was the critical importance of leadership.

From the perspective of responses to the survey's open-ended question, the majority of the comments stemmed from the concept of leadership and culture. Whether a qualitative comment was positive or negative, the message expressed by many survey respondents was the critical importance of leadership. A common theme was expressed by a military mid-level manager: "The human element is the key to success in all endeavors. One must provide true leadership to achieve success." A different military mid-level manager remarked, "DoD and this nation must evolve and mature, with enlightened, informed, driven, and efficient leadership forming the key to this transformation." Another military mid-level manager said, "Leadership has to be… able to take risks and allow freedom for combatants to exercise some risk taking." Regarding the importance of leadership styles, an executive-level civilian noted, "As the external situation changes, the leadership needs to be flexible enough to alter its 'style' to the circumstances." Such remarks were common across numerous respondents who emphasized the importance of leadership in DoD's organizational success.

In addition to the recognition of leadership's importance, direct remarks about how future leaders are developed as part of a formalized DoD process—or lack thereof—were provided. One civilian mid-level manager stated, "The development of future leaders through a systematic, not flow-as-you-go method of mentoring middle-level managers is the MOST [respondent's emphasis] important task an organization can do for its future." A more common remark was the lack of future leader development such as the military mid-level manager who commented about "investing in senior leader development way too late….If you want to build better senior leadership, …then begin educating them sooner and younger." Meanwhile, a civilian mid-level manager observed, "We need individuals to step up and

take more leadership roles in determining what tasks can be prioritized and accomplished and what can be ignored."

The failings of DoD leadership were routinely referenced as part of the survey respondents' feedback, and alluded to an undercurrent of discontent regarding quality of leadership that can be found within DoD. One military mid-level manager wondered "Are these the best leaders we have to do the job?" A civilian mid-level manager noted, "Good mentorship, leadership, and orientation for newcomers is sorely lacking in my organization." One civilian mid-level manager coined a new term to describe his organizational leadership:

> BYOL—Bring Your Own Leadership. Our formal leadership has been routinely bad. In the absence of effective formal leadership, actual leadership has become pretty egalitarian. We are successful because enough reasonable men and women decide that they will somehow succeed—often despite rather than because of—the formal organization.

Discussion

By virtually any standard, leadership has been identified as a critical attribute to an organization's success. With DoD increasingly viewed as an organization that needs to be operated from a business perspective, the value-added from exceptional leadership quality in the development of complex weapon systems can only be viewed as an advantage.

The basic premise behind this article is that such value-added leadership should occur as early as possible within the AT&L Workforce. The current paradigm could serve the warfighter or taxpayers in a more efficient manner. If the current paradigm was working at peak efficiency, DoD would not receive the continual waterfall of studies and reports outlining problem areas with the DAMS in terms of cost, schedule, and/or performance.

In analyzing the results collected for this article, there seems to be widespread interest in improving the quality of leadership throughout DoD, including within the AT&L Workforce. The OCAI survey results shown in Figures 1, 2, and 3 illustrate that both DoD military and civilian personnel indicated a strong preference for a change in leadership style—from the more rigid (market) and bureaucratic (hierarchy) approaches, to approaches that balance family (clan) and risk-taking (adhocracy). The corollary conclusion to be drawn is that the AT&L Workforce is looking for a different leadership approach as compared to what is viewed as the current mode of leadership. With an OCAI survey population including military and civilian members across all rank structures, it would seem a logical extension that the survey results would translate to the AT&L Workforce as

well. So the question becomes, how does the AT&L Workforce gain added expertise in the leadership competency?

This article's data would suggest that the AT&L Workforce would be well served if DAU closely evaluated each Service's PME leadership educational approaches and applied "best practices" to the current acquisition-related curriculum. This conclusion is drawn from the heavy emphasis of the leadership competency at all levels of the Services' PME institutions—not just the senior/executive levels. After centuries of warfare, the military profession has recognized the criticality of quality leadership and justly ensured that this competency is advocated from the very beginning of a warfighter's career. While most of the AT&L Workforce will not see the battlefield during their lifetime, the warfighters, as stakeholders, are nonetheless related to the role played by the AT&L Workforce—delivering the most cost-effective and timely defense weapon systems possible that meet all threshold and as many objective warfighter requirements as possible.

The common thread running through this article's data analysis is that the Service PME institutions highlight the importance of the leadership competency. Meanwhile, DAU—responsible for educating the AT&L Workforce on the functional area roles and responsibilities associated with successfully implementing the DAMS—pays much less attention to the leadership competency in the early stages of DAWIA certification than does the "operational" side of DoD. Yes, at least one DAU course focuses mainly on leadership. And yes, pockets of leadership "modules" are associated with other DAU courses. But all of these points of leadership instruction from within the DAU curriculum are solely focused at the senior/executive level of the AT&L Workforce—exactly the same audience that, when it comes to leadership, possesses the most career experience from which to draw upon.

This approach used by DAU to provide leadership training is a partial solution and a good start. However, instead of concentrating all leadership training assets at the most experienced and senior members of the AT&L Workforce—arguably, AT&L Workforce members who least need leadership training—the workforce would be better served if the DAU approach to leadership training would evolve to one of increasing leadership awareness at the entry- and mid-level segments of the AT&L Workforce. If change is going to occur in stewardship of the DAMS, then those at the "lower levels" need to be fully empowered to initiate changes and enact innovative approaches to better serve the warfighter. Such empowerment and innovation can be enhanced by entry- and mid-level AT&L Workforce members having a better understanding of essential leadership principles.

As noted earlier, advocates of the leadership competency note that DAU's most highly attended course for acquisition professionals—ACQ 201B, Intermediate Systems Acquisition—consists of a single slide discussing leadership qualities. This approach does not adequately express the importance of strong leadership to entry- and mid-level AT&L Workforce members seeking a better understanding of the DAMS. DAU

is rightfully proud of its ability to glean lessons learned from a variety of sources, and then apply those lessons to individual defense acquisition programs as a means of leveraging a "force multiplier" to the procurement of complex weapon systems. DAU now needs to mirror a lessons-learned mind-set from the Services' PME institutions by supplementing the entry- and mid-level acquisition-related courses offered to the AT&L Workforce with a meaningful discussion about the benefits to be gained from the implementation of proper leadership principles.

Conclusions

Conducting business with a "status quo" philosophy will not work if meaningful changes are expected in the procurement of complex defense weapon systems. The creativity and innovation contained within the younger members of the AT&L Workforce—the Generation X'ers and Y'ers—offers a generational opportunity that may provide huge dividends in the battle to improve the efficiency of the DAMS. But this opportunity may never reach fruition if the proper leadership training is not incorporated into the entry- and mid-level DAU acquisition courses. The various Service PME institutions have already shown that any improvement to an organization in terms of leadership performance is partially incumbent upon the proper exposure of foundational leadership principles to the up-and-coming generation of future leaders populating the military's ranks. The same perspective needs to be applied to the AT&L Workforce. That is, if any appreciable change is expected to the structure and implementation of DoD's DAMS, then DAU needs to significantly enhance its treatment of leadership principles available at all levels of the AT&L Workforce membership. By ignoring the leadership attribute that has been proven to be a significant contributor to any organization's success, the entry- and mid-level AT&L Workforce members, in trying to enact meaningful change to implementation of the DAMS, are symbolically "working with their hands tied." DAU stands best positioned to remedy this shortcoming by seriously addressing the importance of leadership.

Author Biography

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THE PRODUCT SUPPORT MANAGER: ACHIEVING SUCCESS IN EXECUTING LIFE CYCLE MANAGEMENT RESPONSIBILITIES

Bill Kobren

In October 2009, President Barack Obama signed the Fiscal Year 2010 National Defense Authorization Act. The legislation (Pub. L. 111-84) contained a provision in Section 805 entitled, "Life Cycle Management and Product Support" requiring: (1) that the Secretary of Defense issue comprehensive guidance on Life Cycle Management (LCM), and the development and implementation of product support strategies for major weapon systems; (2) that each major weapon system be supported by a Product Support Manager (PSM); and (3) that each PSM position be performed by a properly qualified member of the armed forces or full-time employee of the Department of Defense. This article examines the intent, importance, and implications of this provision, and offers recommendations for implementation.

Keywords: *Life Cycle Management (LCM), Performance Based Logistics (PBL), Product Support Manager (PSM), Product Support Integrator (PSI), Life Cycle Logistics (LCL)*

image designed by Harambee Dennis »

Product SUPPORT Managers

And Public Law 111-84

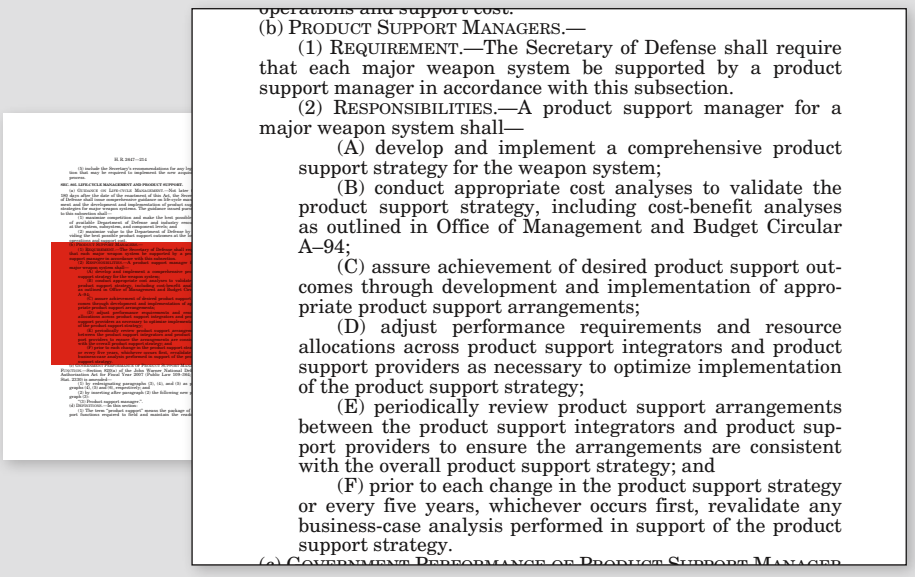
> The Secretary of Defense shall require that each major weapon system be supported by a product support manager…" to "maximize value to the Department of Defense by providing the best possible product support outcomes at the lowest operations and support cost. (NDAA, 2009a, p. 214)

Supporting and sustaining the weapons with which we defend our nation is as old as and indeed pre-dates the establishment of this republic. Yet, as we move beyond the first decade of the 21st century, technology has advanced to the point where weaponry is not only expensive to develop, acquire, operate, sustain, and maintain, but managing the processes and information, and resourcing these tasks have grown commensurately in complexity.

While both the Department of Defense (DoD) and the individual Services each have long-established, well-refined, and detailed processes, policies, and procedures in place to oversee product support management, the processes, titles, responsibilities, and authority vested in the individual charged with ensuring mission-ready, available, and reliable systems have remained fragmented—until now.

The Fiscal Year 2010 National Defense Authorization Act (FY2010 NDAA) was signed into law by President Barack Obama on October

FIGURE 1. STATUTORY LANGUAGE CONTAINED IN SECTION 805 OF THE FY2010 NDAA REGARDING THE NEW PRODUCT SUPPORT MANAGER (PSM)



operations and support cost.

(b) PRODUCT SUPPORT MANAGERS.—

(1) REQUIREMENT.—The Secretary of Defense shall require that each major weapon system be supported by a product support manager in accordance with this subsection.

(2) RESPONSIBILITIES.—A product support manager for a major weapon system shall—

(A) develop and implement a comprehensive product support strategy for the weapon system;

(B) conduct appropriate cost analyses to validate the product support strategy, including cost-benefit analyses as outlined in Office of Management and Budget Circular A–94;

(C) assure achievement of desired product support outcomes through development and implementation of appropriate product support arrangements;

(D) adjust performance requirements and resource allocations across product support integrators and product support providers as necessary to optimize implementation of the product support strategy;

(E) periodically review product support arrangements between the product support integrators and product support providers to ensure the arrangements are consistent with the overall product support strategy; and

(F) prior to each change in the product support strategy or every five years, whichever occurs first, revalidate any business-case analysis performed in support of the product support strategy.

(c) GOVERNMENT PERFORMANCE OF PRODUCT SUPPORT MANAGER

Excerpt from § 805,"Life Cycle Management and Product Support"

28, 2009 (Pub. L. 111-84). Included within the Act is a significant set of legislative provisions that modify DoD procurement policies and practices, particularly § 805, "Life Cycle Management and Product Support" (NDAA, 2009a) (Figure 1).

The law specifically requires (1) that the Secretary of Defense issue comprehensive guidance on *Life Cycle Management (LCM)*, and the development and implementation of product support strategies for major weapons systems; (2) that each major weapon system be supported by a *Product Support Manager (PSM)*; and (3) that each PSM position be performed by a properly qualified member of the armed forces or full-time employee of the DoD (NDAA, 2009b).

Why Mandating a PSM Matters

Changes legislated by the FY2010 NDAA will usher in an era of better performing weapon systems for 21st century warfighters. At least a dozen important benefits result, collectively serving as a basis for better managing LCM responsibilities. The new legislation:

FOCUSES ON DESIRED PERFORMANCE OUTCOMES

First and foremost, the 2009 legislation reiterates commitment by Congress and three presidential administrations to outcome-based weapons systems support and sustainment strategies—a focus that dates back to and even prior to the issuance of the seminal April 1998 Section 912(c) report entitled, "Actions to Accelerate the Movement to the New Workforce Vision" (DoD, 1998). This report was published by then-Secretary of Defense William Cohen in response to the FY1998 NDAA. The desired end state, both then and today, is simple to articulate and remarkably challenging: to attain the highest possible readiness at the most optimal cost (A. Estevez, personal communication, November 30, 2009). LCM and formal establishment of a PSM are two important means of achieving both.

REDUCES PRODUCT SUPPORT COSTS

Weapon system product support costs the DoD approximately $132 billion annually (DoD, 2009a, p. 3), a considerable sum of money by any measure, and a significant portion of the defense budget otherwise unavailable for investment elsewhere in research and development or procurement of new systems. Thus, as the Air Force so aptly articulates, "The primary focus is to optimize life cycle customer support and achieve optimum system availability at the lowest total ownership cost. The life cycle focus on weapon system sustainment cost dictates a seamless, integrated, continuing process to assess and improve product support strategies"

(Department of the Air Force, 2009a). Easier said than done; short of major technological breakthroughs, such outcomes are generally achieved through rigorous application of systems engineering processes, designing with supportability in mind, long-term sustainment planning, aggressive root cause analysis and failure resolution, proactive obsolescence and Diminishing Manufacturing Sources and Material Shortages (DMSMS) mitigation, planned technology upgrades, and perhaps most important of all, a constant focus on system Reliability, Availability, and Maintainability (RAM). An unwavering commitment to LCM principles and practices is therefore an essential prerequisite of life-cycle cost containment.

SUPPORTS ACHIEVEMENT OF KEY DEPARTMENTAL PRIORITIES

In the February 2010 Quadrennial Defense Review (QDR) Report, the Department of Defense reiterated its commitment to acquisition excellence, life-cycle management, outcome-focused sustainment, and public-private partnering by unequivocally stating, "Beyond ensuring that acquisition efforts begin on the right track, the Department must also continue to strengthen the execution phase of weapons development programs… [to] achieve effective life cycle cost management by employing readiness-based sustainment strategies, facilitated by stable and robust government-industry partnerships" (Department of Defense, 2010, pp 78-79). Together, establishment of the PSM position, reiteration of DoD commitment to performance-based sustainment strategies, and establishment of well understood, clearly defined PSM roles, responsibilities, and expectations combine to facilitate fulfillment of the readiness outcomes articulated in the 2010 QDR (Department of Defense, 2010).

SUPPORTS THE PROGRAM MANAGER

"The (law) will ensure that the PSM role is 'clearly designated' within the program offices…bringing the many roles tied to life cycle support under one position" (Munoz, 2009). By policy, the PM is the LCM: "The PM shall be the single point of accountability for accomplishing program objectives for total life-cycle systems management, including sustainment. PMs shall consider supportability, life-cycle costs, performance, and schedule comparable in making program decisions" (DoD, 2007, p. 10). However, PMs cannot fulfill this role alone. In fact, "perhaps no management job in DoD is more demanding. Although the PM is responsible for life cycle support, he can delegate authority to the PSM and now we have doubled the leadership power within the government to effectively accomplish both front- and back-end attention to sustainment" (R. Fowler, personal communication, November 30, 2009). PMs pursue two primary objectives. First, the weapons system should be designed, maintained, and modified to continuously reduce the demand for logistics. Second, logistics support

must be effective and efficient. The resources required to provide product support must be minimized while meeting warfighter needs (Defense Acquisition University, 2005). Establishment of a formal PSM therefore enhances a PM's ability to execute their LCM responsibilities by more clearly defining the duties of a key staff member.

FACILITATES LIFE CYCLE MANAGEMENT

As part of their LCM responsibilities, PMs are charged with identifying, developing, and implementing weapon system product support and sustainment strategies. Specifically, "PMs shall develop and implement *Performance Based Logistics (PBL)* strategies that optimize total system availability while minimizing cost and logistics footprint" (DoD, 2007, p. 7). Moreover, "life-cycle sustainment planning and execution seamlessly span a system's entire life cycle, from Materiel Solution Analysis to disposal. It translates force provider capability and performance requirements into tailored product support to achieve specified and evolving life-cycle product support availability, reliability, and affordability parameters" (DoD, 2008a, p. 28). LCM is therefore about integration, optimization, leveraging capabilities, and achieving readiness, and is clearly not a solo endeavor. The PM requires a capable, empowered, and well-trained team to successfully execute this responsibility.

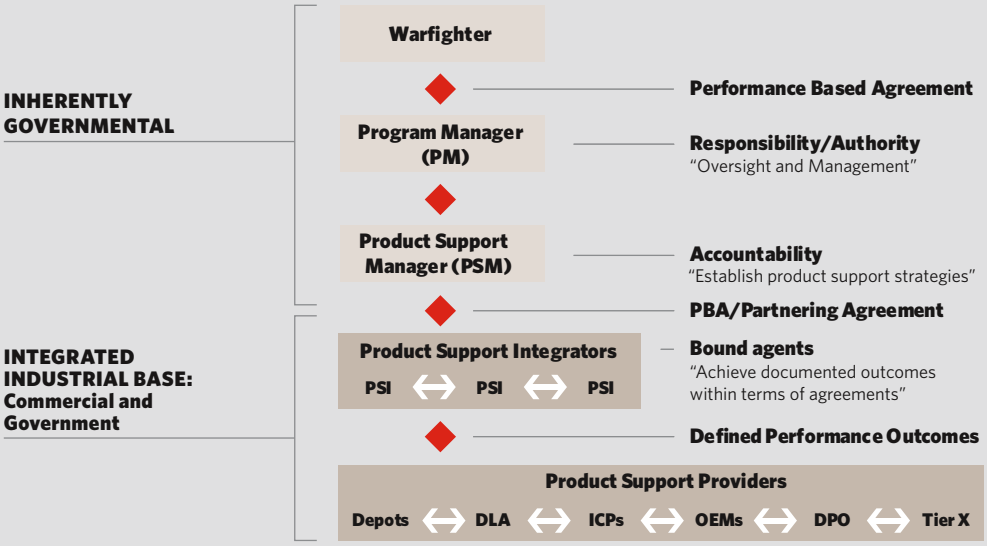
CLEARLY DELINEATES INHERENTLY GOVERNMENTAL FUNCTIONS

"The statute satisfied congressional concerns that in some instances inherently governmental functions were being performed by commercial entities. The language clearly identifies the PSM as the performer of those inherently governmental functions" (A. Estevez, personal communication, November 30, 2009), enhancing government oversight (Figure 2) of product support strategy implementation (Figure 3).

HELPS ACHIEVE LONG-TERM BEST VALUE OUTCOMES

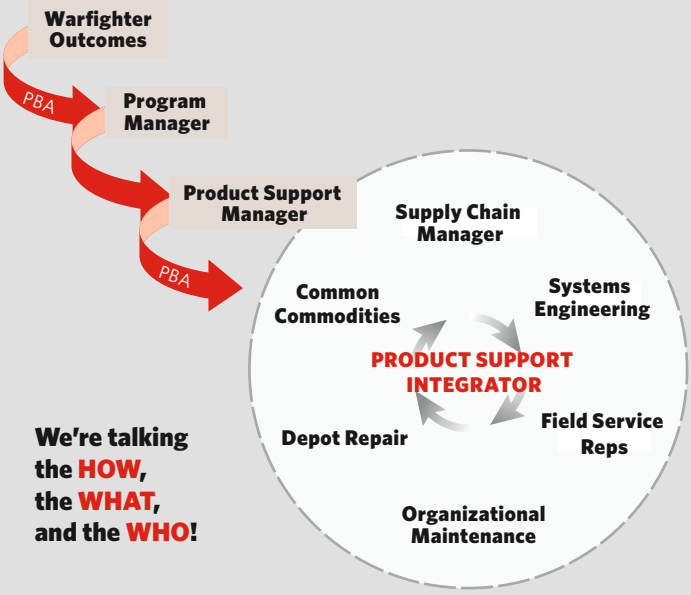
In formally establishing the PSM, Congress reiterated its commitment to weapons systems performance outcomes and life-cycle cost optimization. It also made it abundantly clear that in PBL arrangements, both government and industry entities can serve as product support integrators. Thus, a "clear objective of both Congress and the administration was achieved, namely to maximize competition," and in so doing, also ensuring "long-term best value sustainment strategies that bring a balance between readiness and cost" (A. Estevez, personal communication, November 30, 2009).

FIGURE 2. PRODUCT SUPPORT BUSINESS MODEL



(Source: Fowler, 2009b)

FIGURE 3. WHAT THE PRODUCT SUPPORT INTEGRATOR (PSI) MUST DRIVE AND INTEGRATE



(Source: Fowler, 2009a)

ESTABLISHES CLEAR LINES OF AUTHORITY

Product Support Integration (PSI) is something industry does well, and the Section 805 language allows continued reliance on industrial sustainment integrators. But government organizations can certainly step up and become integrators as well, often in outcome-based partnering strategies with industry providers. In a PBL product support arrangement, "the PSM (acting on behalf of the PM) incorporates the appropriate needs and constraints in agreements with PSIs. They, in turn, ensure that the necessary performance requirements to meet their agreements are properly passed to the lower tier Product Support Providers (PSP), who accomplish the product support activities" (DoD, 2009b, p. 35).

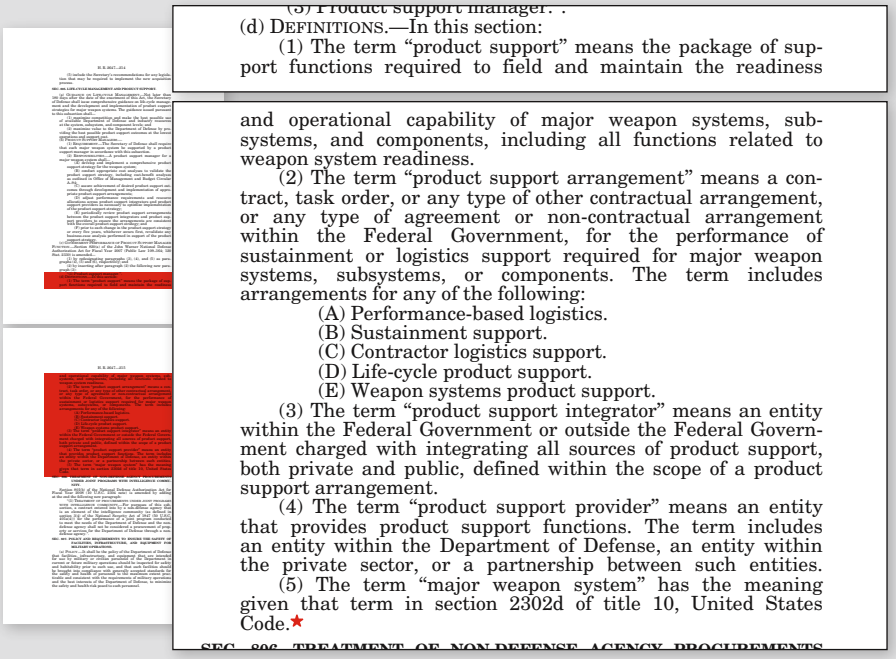
CLEARLY ARTICULATES ROLES AND RESPONSIBILITIES

Although weapon system product support management has been somewhat fragmented in terms of duty titles, specific responsibilities, and individual authority of those charged to deliver it, DoD has long recognized the importance of a PSM. "We've been doing this all along; the intent by clarifying roles and responsibilities is to drive it into the DNA of the program office" (A. Estevez, personal communication, November 30, 2009). Indeed, the *Defense Acquisition Guidebook*, published well before the FY2010 NDAA was signed, specifically outlines PSM responsibilities: "The day-to-day oversight and management of the product support functions are typically delegated to a product support manager…who leads the development and implementation of the performance-based product support strategy and ensures achievement of desired support outcomes. The product support manager, while remaining accountable for system performance, can delegate responsibility for delivering specific outcomes. In doing so, the PM and PSM may employ any number of…support integrators to integrate support from all support sources to achieve the performance outcomes specified in a (PBL) performance-based agreement" (DoD, 2009c, pp. 19-20). Regardless, "the PSM will not be the program manager. It will probably be someone with sustainment or logistics competencies [and] certifications at a given level" (Munoz, 2009) (Figure 4).

STANDARDIZES TERMINOLOGY

The military services use a variety of terms and titles for the PSM, of which the statute only highlighted a few. Not only does this terminology mix tend to be confusing, it risks an "apples to oranges" comparison of duties, responsibilities, and authorities granted to the individuals assigned to these positions, particularly in joint programs. In this instance, standardization of terminology will likely be a welcome, if not overdue change for the acquisition and sustainment community (Air Force, Army, Navy, and Marine

FIGURE 4. FY2010 NATIONAL DEFENSE AUTHORIZATION ACT (NDAA), SECTION 805 DEFINITIONS



(5) Product support manager.''.

(d) DEFINITIONS.—In this section:

(1) The term ''product support'' means the package of support functions required to field and maintain the readiness and operational capability of major weapon systems, subsystems, and components, including all functions related to weapon system readiness.

(2) The term ''product support arrangement'' means a contract, task order, or any type of other contractual arrangement, or any type of agreement or non-contractual arrangement within the Federal Government, for the performance of sustainment or logistics support required for major weapon systems, subsystems, or components. The term includes arrangements for any of the following:

(A) Performance-based logistics.
(B) Sustainment support.
(C) Contractor logistics support.
(D) Life-cycle product support.
(E) Weapon systems product support.

(3) The term ''product support integrator'' means an entity within the Federal Government or outside the Federal Government charged with integrating all sources of product support, both private and public, defined within the scope of a product support arrangement.

(4) The term ''product support provider'' means an entity that provides product support functions. The term includes an entity within the Department of Defense, an entity within the private sector, or a partnership between such entities.

(5) The term ''major weapon system'' has the meaning given that term in section 2302d of title 10, United States Code.★

SEC. 806. TREATMENT OF NON-DEFENSE AGENCY PROCUREMENTS

★ *Includes, but is not limited to, Major Defense Acquisition Programs (MDAP). Title 10 U.S.C. 2302d defines a major weapon system as a system for which the Department of Defense is responsible if total expenditures for research, development, test, and evaluation for the system are estimated to be more than $115,000,000 (based on fiscal year 1990 constant dollars); or the eventual total expenditure for procurement for the system is estimated to be more than $540,000,000 (based on fiscal year 1990 constant dollars).*

Because 10 U.S.C. 2430 defines an MDAP as a DoD acquisition program that is not a highly sensitive classified program and is designated as a major defense acquisition program; or that is estimated to require an eventual total expenditure for research, development, test, and evaluation of more than $300,000,000 (based on fiscal year 1990 constant dollars) or an eventual total expenditure for procurement of more than $1,800,000,000 (based on fiscal year 1990 constant dollars), MDAPs can therefore be considered major weapon systems.

Notes:

1: See also DoD Instruction 5000.02, Enclosure 3, Table 1 (DoD, 2008a) for related descriptions and decision authorities for Acquisition Category (ACAT) I–III programs, including MDAPs.

2: USD AT&L "Directive-Type Memorandum (DTM) 09-027 (DoD, 2009a) revised the DoDI 5000.02 definition of an MDAP to: "a DoD acquisition program that is not a highly sensitive classified program and (1) that is designated by the USD(AT&L) as a MDAP; or (2) that is estimated to require an eventual total expenditure for research, development, test, and evaluation, INCLUDING ALL PLANNED INCREMENTS, of more than $365 million (based on fiscal year 2000 constant dollars) or an eventual total expenditure for procurement, INCLUDING ALL PLANNED INCREMENTS, of more than $2.19 billion (based on fiscal year 2000 constant dollars)."

Corps Representatives to the DoD Life Cycle Logistics Functional Integrated Process Team [FIPT], personal communications, November 13-24, 2009; Department of the Air Force, 2009b). Some current titles include the following:

- The Air Force generally uses *Director of Logistics (DOL)* terminology in their acquisition product centers and *System Sustainment Manager (SSM)* for programs in sustainment.
- The Navy uses terms such as *Director of Logistics, Assistant Program Manager for Logistics (APML),* and *Deputy Assistant Program Manager for Logistics (DAPML).*
- The Marine Corps uses several terms for logistics leadership in a program office, including *Program Management Team Life Cycle Logistician (PMT LCL)*, *PM Lead LCL,* and *Strategic Business Team LCL.*
- The Army uses a variety of titles, including *Deputy Program Manager for Logistics (DPML), Associate Program Manager for Logistics (APML), Executive Director for Logistics, Associate Director for Logistics,* and *Logistics Division Chief.*

ENCOURAGES DEVELOPMENT OF APPROPRIATELY RIGOROUS, TARGETED TRAINING

DoD *Life Cycle Logistics (LCL)* training provided by the Defense Acquisition University (DAU), while robust and competency-based, is not specifically tailored for, or directly targeted at, the executive level and/or senior logistician in a program office. This inevitably leads to the question of whether an individual with Level III LCL certification has received sufficient training, has mastered the requisite competencies, or has demonstrated proficiencies required for success as a PSM.

FURTHER INTEGRATES ACQUISITION AND SUSTAINMENT

The ultimate "goal is to ensure sustainment considerations are integrated into all planning, implementation, management, and oversight activities associated with the acquisition, development, production, fielding, support, and disposal of a system across its life cycle" (DoD, 2009c, p. 5). This is critical, since at the end of the day, the PSM is the individual who will be tasked to "carry that ball across the goal line" on behalf of the PM.

Implications and Intent

In adopting the Section 805 language, the House and Senate conferees were extraordinarily clear in articulating their intent, specifically emphasizing the following provisions (NDAA, 2009b, p. 779):

- "Product support encompasses all critical functions related to weapon-system readiness, including materiel management, distribution, technical data management, maintenance, training, cataloging, configuration management, engineering support, repair parts management, failure reporting and analyses, and reliability growth.
- Included within logistics and sustainment functions are the tasks normally performed as part of the logistics support required for a major weapon system that are designed to focus on such metrics as readiness, reliability, availability, mean down time, customer wait time, footprint reduction, and reduced ownership costs....
- In implementation of this provision, the positions of product support manager, assistant program manager for logistics, deputy program manager for logistics, and system support manager shall be considered synonymous....
- The product support manager is a separate position from the program manager with distinct responsibilities" and "each such position [shall] be performed by a properly qualified member of the armed forces or full-time employee of the Department of Defense."
- By passing this language, they "in no way intend to limit DoD from establishing product support managers and comprehensive product support strategies for other acquisition programs that are not designated major weapon systems."

What Does This Actually Mean?

> Product support, also referred to as system sustainment, is the package of support functions required to maintain the readiness and operational capability of weapon systems, subsystems, software, and support systems. (DoD, 2009b, p. 7)

The nine imperatives covered in the following discussion constitute the author's view of what the FY2010 NDAA legislation means to the life cycle logistician and industry counterparts:

IT'S ALL ABOUT THE WARFIGHTER AND NATIONAL SECURITY

President Obama, signed the FY2010 NDAA into law on October 28, 2009, containing language that stated, "Our defense budget isn't about politics, it's about the security of our country, and who knows that every dollar wasted is a dollar we can't spend to care for our troops or protect the homeland." Ultimately, the 2010 NDAA is all about supporting the warfighter and ensuring our national security—something formal establishment of a PSM helps to achieve.

PRODUCT SUPPORT APPLICATION BROADER THAN LOGISTICS

Clearly, product support, while primarily a logistics and sustainment function, is not actually synonymous with logistics. Indeed, product support "encompasses materiel management, distribution, technical data management, maintenance, training, cataloging, configuration management, engineering support, repair parts management, failure reporting and analysis, and reliability growth" (DoD, 2009b, p. 7). Product support (and LCM for that matter) is therefore truly a "team sport," requiring involvement, engagement, resources, expertise, and support from across the acquisition and sustainment domains, including from program managers, contracting officers, systems engineers, business and financial managers, and logisticians of varying backgrounds, including, of course, life cycle logisticians.

ENHANCED LIFE CYCLE MANAGEMENT

LCM is an essential element in minimizing life-cycle costs and maximizing weapon system performance and availability, a point repeatedly emphasized in DoD acquisition guidance. Establishing a PSM to assist in carrying this out enhances prospects for successfully achieving true LCM outcomes, while providing for greater flexibility in determining long-term product support and sustainment resourcing requirements, and establishment of subsequent resourcing decisions. "Maintaining flexibility

for long-term product support strategies is a key ingredient of the new statute" (R. Fowler, personal communication, November 30, 2009).

APPLICABILITY TO MAJOR WEAPON SYSTEMS

Words matter. The decision to use the term "Major Weapon System" in the statute has several advantages over mandating a PSM requirement solely for Major Defense Acquisition Programs (MDAP) (see Figure 4 for statutory versus DoDI 5000.02 differences in definitions). First, it ensures PSMs will be assigned to MDAPs, but does not limit the positions only to those programs, thus ensuring PSMs can be assigned to other programs not meeting MDAP designation dollar thresholds. Second, it communicates the intent that the position of PSM and its inherent responsibilities are for the life of the program, and do not culminate at system fielding. Third, once trained, this broader pool of experienced personnel capable of serving in a PSM capacity affords the Services greater flexibility in hiring the right individuals to serve as PSMs in the critically important, highly visible MDAPs.

BETTER MANAGED WEAPON SYSTEM SUPPORT

An *Aviation Week* feature article (Tegtmeier, 2009) highlighted the coming shift in military sustainment support. Section 805 of the bill fundamentally changes the way industry and government manage major weapon system support, according to Lynn Williams, a staff member of the House Armed Services Committee. Section 805 of the bill fundamentally shifts high-level aftermarket responsibility to the government and takes over some resource allocation from private industry. It also requires that each major weapon system be supported by a product support manager who is a member of the armed services or a full-time employee of the Defense Department. By considering sustainment requirements in early acquisition discussions, Williams believes, as do so many others, that product support costs should actually decrease (Tegtmeier, 2009).

ENHANCED CREDIBILITY OF PBL AS A WEAPON SYSTEM PRODUCT SUPPORT STRATEGY

The PSM will play a key role in implementation of PBL and assembling the team charged with developing and executing that product support strategy. Both the Navy (J. Heron, personal communication, December 7, 2009) and the Army, for example, recognized this well before the legislation was signed, the latter stating, "a PBL team should be formed to manage the PBL effort. The team, led by the PM or the PM's designated product support manager (PSM), shall consist of government and private-sector functional experts and shall include all appropriate stakeholders, including warfighter representatives" (Department of the Army, 2009, pp. 20-21).

GOVERNMENT AND INDUSTRY ROLES CLARIFIED

Although both the June 2009 *Defense Acquisition Guidebook* and the March 2005 *Performance Based Logistics: A Program Manager's Product Support Guide* address both the PSM and PSI, as guidebooks they lack the authority of either policy or statute. Even so, many misconceptions about PSI and PSM organizations and responsibilities persist. "What [Congress] is trying to do is clarify…that we have an inherently governmental function; it is performed by this product support manager; and here are the elements of that function" (Munoz, 2009). Section 805 reiterates that the PSM position is an inherently governmental role. The PSM therefore directly supports the PM and retains oversight of PBL implementation. The PSI, on the other hand, can come from both government and industry, and supports both the PM and PSM by integrating (and in some cases providing) sources of product support.

PM-PSM RELATIONSHIP BETTER UNDERSTOOD

PMs are responsible for "ensuring product support integration as a continuous and collaborative set of activities that establish and maintain readiness and the operational capability of a system, subsystem, or end-item throughout its life cycle" (Department of the Air Force, 2009b, p. 50). Moreover, "the PM shall ensure that integrated logistics support objectives are considered and introduced as early as practical with a far-reaching life cycle view concerning logistics design and supportability of the system" (Department of the Air Force, 2009b, p. 113). Although the PM is ultimately accountable for LCM of the system, the senior program logistician, among others in a program office, is responsible for development of long-term support and sustainment planning. The PSM, like all life cycle logisticians, is charged with "translating warfighter performance requirements into tailored product support spanning the system life cycle" (DAU, 2009, p. 76). To achieve this, the PSM must be a strong proponent of LCM principles, objectives, and implementation, articulating the importance of long-term product support considerations as design trade-offs are made during system development. The synergy, collaboration, and integration required between the PSM and the PM in terms of successfully executing LCM and product support responsibilities are unmistakable.

CLEARLY ARTICULATED EXPECTATIONS

DoD defines LCL as "the ability to plan, develop, implement, and manage comprehensive, affordable, and effective systems support strategies…encompass(ing) the entire system's life cycle, including acquisition (design, develop, test, produce, and deploy), sustainment (operations and support), and disposal" (DoD, 2008b, p. 16). The similarities

to the expectations outlined by Congress in the FY2010 NDAA and by DoD in the November 2009 Product Support Assessment report for the PSM are clear, and as would reasonably be expected, not coincidental. PSMs, by and large, will be drawn from among the best, brightest, and most expert life cycle logisticians in the department. The key is to ensure they are trained, equipped, and have the resources, tools, and fortitude to successfully address the challenges, responsibilities, and expectations levied upon them.

Recommendations

> Reformed [product support] stewardship—driven by improving product support and achieving more cost-effective weapon system readiness outcomes—requires a life-cycle management focus, committed leadership, and cooperative efforts from the operational, acquisition, and logistics communities. (DoD, 2009b, p. 3)

Thus far, this article has outlined the intent, importance, and implications of the Section 805 provisions of the FY2010 NDAA legislation regarding LCM and product support. Developing the implementation policy is the responsibility of the Office of the Secretary of Defense, while implementation of the provisions of that policy is the responsibility of Components and their materiel, systems, and/or logistics commands; however, the following recommendations are provided from the author's perspective as a career logistician, to facilitate PSM policy implementation and offer some thoughts on things it will take in the areas of LCM and product support to more effectively support and sustain the weapon systems with which we defend our nation.

RECOMMENDATION NO. 1: DoD POLICY CONSIDERATIONS

Section 805 requires the Secretary of Defense, specifically the Office of the Under Secretary of Defense (Acquisition, Technology & Logistics), to issue comprehensive LCM guidance and develop product support strategies within 180 days after enactment. As part of this policy, DoD should consider:

Updating DoDD 5000.01, DoDI 5000.02, the Defense Acquisition Guidebook, and Performance Based Logistics: A Program Manager's Product Support Guide to encapsulate PSM roles, responsibilities, and relationship to the PM. This guidance should also include additional tools, resources, and guidance to support the PSM in performing duties, including creation of a new Enclosure 13 to DoDI 5000.02 to address many of the recommendations from the Product Support Assessment report. Several to consider include establishing Sustainment Readiness Levels (SRL) akin to existing Technology Readiness Levels, mandating standardized Independent Logistics Assessments

(ILA) at regular intervals in a program life cycle, and ensuring regular post-fielding program reviews and evaluation of sustainment funding, readiness, and sustainment outcome metric achievement.

PSM location and reporting chain. Ideally the PSM would be assigned to the program office and report directly to the program manager. Although in some instances it may be more advantageous to have the PSM collocated with a depot, logistics command/center, or field support activity (authorized by DoDI 5000.02) (DoD, 2008a, p. 72), ensuring strategic PM-PSM alignment and linkage of long-term product support objectives, direction, and strategy development are imperative, and would be best enabled by a direct reporting chain to the PM, regardless of location.

RECOMMENDATION NO. 2: ESTABLISH RIGOROUS REQUIREMENTS FOR PSM SELECTION

To ensure only the most qualified personnel are selected by the military services to serve as PSMs, update the December 21, 2005, issuance of DoDI 5000.66, *Operation of the Defense Acquisition, Technology, and Logistics Workforce Education, Training, and Career Development Program* (DoD, 2005, p. 3) to:

- Designate the PSM position as both a Critical Acquisition Position (CAP) and a Key Leadership Position (KLP) for all major weapon systems, including Major Defense Acquisition Programs/Major Automated Information Systems (MDAP/MAIS) to reflect the new statutory authority given in the FY2010 NDAA.
- Add the PSM as a position that should be considered for designation as a KLP for significant non-MDAPs, recognizing the key role the PSM plays in executing LCM and program sustainment across the system life cycle.
- Identify specific and rigorous experience, training, and education requirements that go beyond existing requirements for Level III LCL certification. In addition to other DoDI 5000.66 CAP/KLP requirements, these should include:
  - At least 8 years' acquisition experience, which includes at least 6 years in LCL, with at least 2 years in a program office or similar organization.
  - Level III certification in LCL.

RECOMMENDATION NO. 3: EXPAND OPPORTUNITIES FOR MILITARY PERSONNEL TO SERVE AS PSM

Undertake initiatives to expand the number of uniformed military personnel in the LCL career field to ensure a pipeline of talented, experienced, trained, and certified personnel possessing both acquisition and operational backgrounds is available to fill key PSM positions, along with their civilian counterparts. According to DoD Instruction 5000.66, the Under Secretary of Defense (Acquisition, Technology & Logistics) shall "identify appropriate career paths for civilian *and military personnel* [emphasis added] in the AT&L Workforce in terms of education, training, experience, and assignments necessary for career progression to the most senior AT&L positions" (DoD, 2005, p. 4). Moreover, the instruction goes on to task the heads of DoD Components (acting through their Component Acquisition Executives) to not only "provide opportunities for both civilian and *military members* [emphasis added] of the AT&L Workforce to acquire the education, training, and experience necessary to qualify for senior positions" (DoD, 2005, p. 4), but also to "assign military officers to provide a balance between career-broadening experience and sufficient time in each position to ensure accountability, responsibility, and stability" (DoD, 2009b, p. 68). Regrettably, only 931 military personnel are assigned to DoD LCL positions, representing just 6 percent of the coded positions in the career field (Figure 5). Of these, none come from the Army or the Fourth Estate (Defense Agencies), and a total of just 64 military personnel are currently certified at Level III. Ensuring a sufficiently robust pool of experienced, talented, trained, and operationally experienced uniformed military personnel to complement their civilian counterparts will go a long way toward ensuring the success of the PSM requirement.

RECOMMENDATION NO. 4: IMPLEMENT DoD PRODUCT SUPPORT ASSESSMENT HUMAN CAPITAL RECOMMENDATIONS

DoD should aggressively implement key recommendations contained in the November 2009 DoD Product Support Assessment report in order to provide the PSM, the PM, the DoD Components, and the department the ability to successfully achieve congressionally mandated Section 805 requirements, and in the process, increase competition, enhance performance based life-cycle product support, reduce life-cycle costs, and improve weapon system performance outcomes. Development of more robust analytical tools, policies, and processes for performing business case analyses, better oversight of operations and sustainment costs, and expanding public-private partnering are all strategic initiatives, among many others, which complement Section 805 direction. This would also include aligning human capital report recommendations with PSM roles, responsibilities, and authority to "identify new or modified product support

FIGURE 5. AT&L LIFE CYCLE LOGISTICS FUNCTIONAL AREA AS OF DECEMBER 31, 2009

Career Level Achieved	Workforce Category	Army	Navy	Air Force	4th Estate	Total
Level I	Civilian	1,901	745	348	12	3,006
	Military	-	114	104	-	218
Subtotal		**1,901**	**859**	**452**	**12**	**3,224**
Level II	Civilian	1,560	1,169	466	29	3,224
	Military	-	57	40	-	97
Subtotal		**1,560**	**1,226**	**506**	**29**	**3,321**
Level III	Civilian	2,214	1,553	261	61	4,089
	Military	-	56	8	-	64
Subtotal		**2,214**	**1,609**	**269**	**61**	**4,153**
No Level Achieved/ Unknown	Civilian	2,637	966	465	20	4,088
	Military	-	237	315	-	552
Subtotal		**2,637**	**1,203**	**780**	**20**	**4,640**
Totals		**8,312**	**4,897**	**2,007**	**122**	**15,338**

(*Source: AT&L Workforce Data Mart)*

competencies and proficiencies driven by proposed (product support assessment) strategy, policy, and process changes" and to "incorporate new or modified product support competencies into DoD and industry logistics, and acquisition workforce career field training, recruitment, and retention strategies" (DoD, 2009b, p. 69), including:

- Focusing on enhancing professional development, including greater emphasis on the seven key life cycle logistics competencies outlined in the May 2008 DoD Logistics Human Capital Strategy (Logistics Design Influence, Integrated Logistics Support Planning, Product Support & Sustainment, Configuration Management, Reliability & Maintainability Analysis, Technical/Product Data Management, and Supportability Analysis) (DoD, 2008b, p. 4) and underlying proficiencies, which serve as the building blocks for each competency.
- Developing highly capable, highly effective PSMs with a truly strategic, enterprise-level perspective. Such individuals would possess the experience of what the DoD Logistics Human Capital Strategy terms a "multi- faceted logistician with expertise in many segments and knowledge of the logistics process end-to-end; knowledge of business or

other fields; executive training; and multi-component experience" (DoD, 2008b, p. 4).

- Establishing more rigorous, competency-based defense acquisition workforce certification training, including new DAU courses focusing on RAM, supportability analysis, technical data/product data management, and expanded performance based life-cycle product support and sustainment courseware to strengthen preparation of future PSMs during their acquisition professional development.
- Identifying executive-level PSM competencies and development of 400-level training for PSMs comparable to existing PMT 401 and PMT 402 training currently available for senior program managers. Moreover, because product support is broader than LCL, this would entail going beyond a logistics audience and identifying executive-level product support competencies and training for other acquisition functional career fields.

RECOMMENDATION NO. 5: ALIGN EXISTING POLICY WITH NEW STATUTORY REQUIREMENTS

First and foremost, DoD Section 805 implementation guidance will need to address a variety of LCM enablers related to competition, best value determination, resource allocation, business case analysis, strengthening outcome-based product support implementation, long-term sustainment oversight, and of course, PSM roles, responsibilities, and authority. In addition, with codification of the PSM position into law, Service-specific guidance such as direction contained in Air Force Instruction 61-101, "identify a *product support integrator* as a single point of contact prior to program initiation" and "the product support integrator will be military or government civilian personnel unless otherwise approved and documented as part of program planning" (Department of the Air Force, 2009b, p. 113) should be revised to reflect the fact that the PSM must be either military or a government civilian, and at the same time, PSI responsibilities under a PBL arrangement can be performed by either a governmental or industry organization. Section 805 of the FY2010 NDAA clearly states "the term 'product support integrator' means an entity within the Federal Government *or outside the Federal Government* [emphasis added] charged with integrating…sources of product support, both private and public, defined within the scope of a product support arrangement" (NDAA, 2009a).

Conclusions

> Planning for Operations and Support and the estimation of total ownership costs shall begin as early as possible. Supportability, a key component of performance, shall be considered throughout the system life cycle. (DoD, 2007, p. 10)

DoD is at a critical juncture. Supporting and sustaining increasingly complex, often aging weapon systems in an era of budgetary austerity, and faced with a variety of threats and challenges from both state and non-state actors, the department must leverage LCM processes, practices, and policies, coupled with performance based life-cycle product support sustainment strategies to preclude degraded readiness and upward spiraling support costs. By including Section 805 in the FY2010 NDAA, Congress has made it clear where it stands on these issues, and who is responsible for addressing them. "The true decision-making authority lies with the product support managers, who determine 'allocation decisions, strategy decisions, doing the business case analysis to determine the best approach for sustaining the weapons system'" (Munoz, 2009).

The confluence in recent months of formal statutory recognition of the PSM, issuance of a DoD Logistics Human Capital Strategy capturing the vision and required competencies, recognition by the department that performance based logistics strategies must be strengthened and broadened to more effectively inculcate product support (of which logistics is an important, but by no means exclusive subset), and issuance of a year-long DoD Product Support Assessment report all point to the same desired outcome: genuine LCM, which delivers sustained long-term weapon system readiness while optimizing life-cycle costs. The stars are aligned for product support success like never before.

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HOW WELL ARE PMs DOING? INDUSTRY VIEW OF DEFENSE PROGRAM MANAGER COUNTERPARTS

Roy L. Wood

Large, complex defense acquisition programs have been plagued by cost overruns, delayed schedules, and subpar performance. Much of the responsibility has been attributed to weaknesses in competencies of government program managers (PM). This study provides a new perspective on government PM competencies by surveying defense industry managers who work with the government PMs. Data gathered from a survey of 146 industry managers rated the importance of common PM competencies and assessed how well, from their perspective, their government counterparts met those competencies. The data also revealed several insights, including a conclusion that government PM performance on several key technical skills may need improvement. The results of this study will be useful in assessing training and development strategies for government PMs.

Keywords: *Program Management, Competencies, Skills, Leadership, Organizational Behavior*

image designed by Miracle Riese »

Surveying you!

The Government Accountability Office (GAO), an independent investigative arm of the U.S. Congress, reported in 2008 that the Department of Defense (DoD) had $1.6 trillion in commitments for weapons systems acquisition programs, with estimated cost growth of $295 billion and average schedule delays of 21 months (GAO, 2008, p. 4). Indeed, for the past several decades, news reports of $600 toilet seats, poor performance of battlefield equipment, and cancelled programs have been all too commonplace (Besselman, Arora, & Larkey, 2000; Samuel, 2003). The Defense Acquisition Program Assessment (DAPA) Report of 2006 (Kadish, 2006) more recently asserted that:

> Both Congress and the Department of Defense senior leadership have lost confidence in the capability of the Acquisition System to determine what needs to be procured or to predict with any degree of accuracy what things will cost, when they will be delivered, or how they will perform. (p. 1)

DoD program managers (PM) have come to bear much of the responsibility for these overruns in cost and schedule (GAO, 2005; Kadish, 2006). In the DAPA report, "program manager's expertise" was identified as one of the top five issues contributing to the poor program performance (Kadish, 2006, p. 3); and in 2008, the GAO commented that the DoD needed to "strengthen training and career paths as needed to ensure program managers have the right qualifications for running the programs they are assigned to" (Sullivan, 2008, p. 16). Part of the solution to improving acquisition program outcomes, then, may lie in identifying and improving specific *competencies* of the program managers themselves.

This is not a simple undertaking. Most who understand the job of the program manager in defense acquisitions appreciate the breadth of knowledge, *skills*, and abilities he or she must possess in several competencies, including:

- The PM must be *technically* competent, able to manage technology and system engineering as well as software and information systems, and understand manufacturing and industrial processes.
- The PM must demonstrate key *business* competencies such as financial management, contracting, and cost estimating.
- The PM must exercise *leadership and management* competencies in developing and executing the program strategy, managing core processes, and dealing with the day-to-day management challenges of a large, complex program.

Fox and Miller (2006) summed up the need for this broad and comprehensive PM competency set by stating:

> Managing [a large complex project] is more than a science; it is a continually evolving art… Managers must augment a strong foundation of conventional management skills in planning, organizing, and controlling, with knowledge of the requirements, resources, and constraints of a specific project as it progresses. (p. 109)

Given the expansive portfolio of required competencies, one might question whether some competencies are more important to program success than others. For example, research by Bauer (2006), asserted that *management* competence is more important for defense and aerospace industry program managers than *technical* competence. Likewise, Gadeken (2004) reported research from government PM self-assessments that suggested leadership and management skills were more important than technical skills.

Once critical PM competencies are identified, the next logical inquiry would be into which of those competencies PMs might be demonstrating systemic weaknesses. If important competencies can be identified, and weaknesses among those discovered, perhaps focused training and development remediation can be applied to improve these PM competencies, and thus impact program performance.

To try to address this opportunity, this exploratory, quantitative study began with a set of 35 specific technical/business ("hard skill") and leadership/management ("soft skill") competencies and attempted to determine which were perceived as most important in contributing to program success, and how well PMs were performing against those competencies. To minimize bias associated with self-surveys, a sampling of experienced defense industry managers was invited to participate in a survey that asked them to objectively assess the skills and abilities of their government counterparts. This approach provided a unique perspective on government PM competencies that had not been explored previously in the literature.

Research Method

While most competency studies in the literature involved collecting data from PM self-surveys or, in some cases, surveys of PM supervisors (Besner & Hobbs, 2006; Cheng, Dainty, & Moore, 2005; Gehring, 2007; Muzio, Fisher, Thomas, & Peters, 2007), this study attempted to use a fresh approach. Here, defense *industry* PMs were surveyed and asked to provide their perceptions and assessments of the core competencies of

their government counterparts. Industry PMs were selected because they are in a singularly distinctive position to be able to assess their government PM equivalents. Government and industry PMs typically work very closely together on defense programs, providing the unique opportunity for these industry managers to closely observe their government PM counterparts and contribute rare and valuable insights to this study.

Key competencies of the government PMs were measured using a survey instrument originally developed by Golob (2002). The survey instrument was based in part on Project Management Institute (PMI) competencies and modified for the purposes of this investigation. Survey validity and reliability were verified through expert evaluation, pilot surveys, and standard statistical methods.

The competencies included 20 technical/business, or "hard skills," and 15 leadership/management, or "soft skills," as shown in Table 1. Survey participants were asked to address two questions. First, which government project management competencies among the 35 given are most important for program success? Participants responded to the list of competencies, rating the relative contribution of each to program success. Each competency was listed on the questionnaire with Likert scale choices of *Very Important, Important, Neutral, Unimportant,* or *Very Unimportant*. The second research question put to the industry managers was how well government PM counterparts performed against each competency. The Likert scale observations included ratings of *Expert, Good, Average, Fair, Poor,* and a no-response choice.

Participating in the survey were 146 industry managers, providing a good statistical basis for insights into PM competencies. Demographic information from the survey revealed that the sample included a large proportion of senior industry managers with substantial experience managing complex defense programs. The survey demographics are depicted in the Figure. The data also show that the industry managers had frequent contact with their government counterparts, lending credence to their observations.

Results

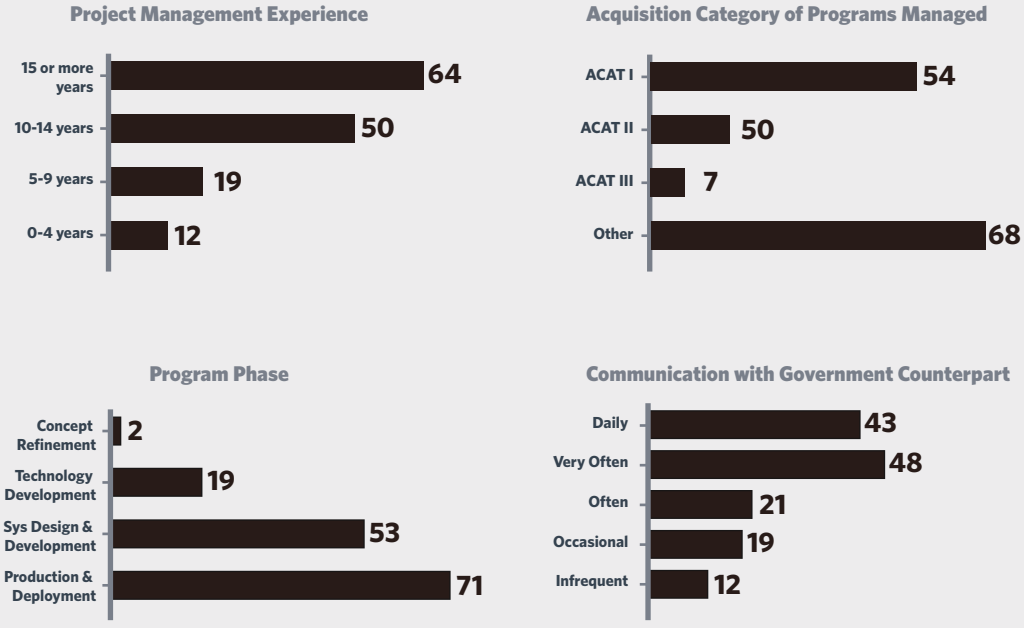
COMPETENCY IMPORTANCE TO PROGRAM SUCCESS

To address the importance of each competency to program success, the mean scores for each competency were compared and rank ordered. A higher average score indicated that the industry managers perceived this particular competency to be a more important determinant of program success. Table 1 shows the means ranking of the importance data. Since the survey was based on a mature set of widely accepted competencies,

TABLE 1. SURVEY COMPETENCIES AND DEFINITIONS

Hard Skills (C1–C20)	
1.	Determine program goals, requirements, and specifications
2.	Determine program scope and deliverables
3.	Technical ability
4.	Document program constraints that could affect program completion
5.	Document program assumptions
6.	Define program strategy or alternative approaches
7.	Quality assurance
8.	Identify resources requirements
9.	Develop a budget
10.	Create a work breakdown structure (WBS)
11.	Develop a schedule
12.	Develop a resource management plan
13.	Establish program controls comparing actual against planned performance
14.	Develop program plan
15.	Communicate program status
16.	Measure program performance to identify program trends and variances
17.	Implement corrective action
18.	Implement change control
19.	Respond to risk
20.	Conduct administrative closure of the program upon completion
Management/Leadership (Soft Skill) Competencies (CS1-15)	
1.	Project leadership
2.	Flexibility to adapt and deal with situations and manage expectations
3.	Sound business judgment
4.	Trustworthiness
5.	Communication style presents clear and unambiguous information without bias
6.	Listening skills
7.	Setting and managing expectations
8.	Negotiations
9.	Issue and conflict resolution
10.	Organizational skills
11.	Coaching
12.	Facilitation
13.	Decision making
14.	Problem solving
15.	Team building

FIGURE 1. SURVEY DEMOGRAPHICS



industry managers rated most of the competencies very highly in importance to project success.

The highest rated competencies represented a relatively even mix of technical and soft skills. The most valued hard skills were the ability to *determine program goals and deliverables* and *develop a program budget.* These results were not surprising. Among others, Pinkerton (2003, p. 53) pointed out that the first criterion for project success is to have clearly defined goals and objectives. It is important for the government to specify the deliverables from the project, and it is equally important for industry, because deliverables define the government's expectations in concrete terms. Similarly, a sound program budget is important to match resources to goals and deliverables.

The most highly rated soft skills included *trustworthiness, project leadership,* and *decision making.* Trust and trustworthiness are keys to proper organizational and interorganizational functioning and have been documented in the literature (Jehn & Mannix, 2001; Joseph & Winston, 2005; Wells & Kipnis, 2001). Trust may be particularly important in large, complex projects where not every expectation can be instantiated in the government-industry contract. Trust and understanding between the government and industry managers are essential to minimize conflict, foster cooperation, and jointly succeed.

Similarly, project leadership in a complex defense project is required to establish the vision and goals, motivate the team, and gain commitment to program success. The third-ranking attribute, PM decision making, is

TABLE 2. COMPETENCY SCORES FOR IMPORTANCE

Competency Designation	Competency Description	M	SD	Ranking by Mean
C 1	Determine program goals	4.86	0.345	1
C 2	Determine program deliverables	4.75	0.478	2
C 3	Technical ability	4.14	0.533	28
C 4	Document constraints	4.47	0.634	9
C 5	Document assumptions	4.18	0.599	26
C 6	Define program strategy	4.38	0.624	15
C 7	Quality assurance	4.10	0.782	29
C 8	Identify resources needs	4.30	0.626	22
C 9	Develop a budget	4.62	0.578	5
C 10	Create a WBS	3.85	0.861	34
C 11	Develop a schedule	4.53	0.645	8
C 12	Develop a resource mgt plan	4.02	0.815	31
C 13	Establish program controls	4.44	0.664	11
C 14	Develop program plan	4.37	0.752	18
C 15	Communicate status	4.27	0.638	23
C 16	Measure performance	4.35	0.594	20
C 17	Implement corrective action	4.47	0.553	10
C 18	Implement change control	4.31	0.739	21
C 19	Respond to risk	4.41	0.607	13
C 20	Administrative closure	3.66	0.771	35
C S1	Project leadership	4.65	0.493	4
C S2	Flexibility	4.42	0.549	12
C S3	Business judgment	4.36	0.560	19
C S4	Trustworthiness	4.75	0.452	3
C S5	Communication style	4.21	0.528	25
C S6	Listening skills	4.27	0.567	24
C S7	Set and manage expectations	4.40	0.557	14
C S8	Negotiation	4.38	0.623	17
C S9	Issue and conflict resolution	4.16	0.547	27
C S10	Organizational skills	4.05	0.608	30
C S11	Coaching	4.01	0.712	32
C S12	Facilitation	3.85	0.709	33
C S13	Decision making	4.60	0.533	6
C S14	Problem solving	4.38	0.590	16
C S15	Team building	4.54	0.578	7

Note. C = Technical Skill; CS = Soft Skill

also important since most decisions require the PM to delicately balance program goals and powerful stakeholder interests. Complex program decisions reflect *organizational behavior* factors involving resolution of conflicting program goals, and avoidance of uncertainties that can create program risk (Cyert & March, 1958).

Competency Performance

A similar means analysis was also conducted to allow rank ordering of the data for the second question of whether the government PMs were perceived as meeting the expectations for each of the competencies in the study. Table 2 shows the means ranking of the performance data. Noteworthy (and perhaps a bit disturbing) is that the performance scores *for all competencies* generally rated only near average. This overall result can only be considered surprising and not a little disappointing, given the high stakes and inherent expectations that defense PMs are capable of managing billions of taxpayer dollars and providing critical defense systems to the battlefield. The results seem to indicate that government skills could generally use additional developmental improvement across the entire spectrum of hard and soft skills.

Closer examination of the data nearer the bottom of the performance range reveals items with lower perceived performance, such as the PMs' ability to *implement change control, develop a resource management plan,* or *provide coaching.* In absolute terms, these are important insights to areas where training and development could potentially help improve skills. However, since many of the items have poor survey assessments, it becomes important to weight the findings by importance to be more discerning of the areas where improvements might yield greater value.

Determining the Competency Gap

In order to judge the relative size of the performance gap in PMs' meeting important competencies, the results of the two rankings—importance and performance—were compared and more closely analyzed. The assessment approach for this analysis was based on the Borich weighting model (1980). In this model (Table 3), the difference between the mean assessed ability to meet a competency was compared to the mean perceived importance to measure/identify the magnitude of the discrepancy. This discrepancy score was then multiplied by the competency importance to garner a weighted score.

By using this method, items with the largest gap between importance and performance migrated to the top of the list, reflecting a more finely prioritized list of important competencies with larger shortfalls. For

TABLE 3. COMPETENCY PERFORMANCE DATA

Competency Designation	Competency Description	M	SD	Ranking by Mean
C 1	Determine program goals	3.42	0.911	4
C 2	Determine program deliverables	3.27	1.015	10
C 3	Technical ability	3.45	1.043	2
C 4	Document constraints	2.98	1.029	27
C 5	Document assumptions	2.97	0.958	29
C 6	Define program strategy	3.03	1.032	24
C 7	Quality assurance	3.32	0.816	7
C 8	Identify resources needs	3.04	1.068	23
C 9	Develop a budget	2.90	1.121	31
C 10	Create a WBS	3.05	0.991	21
C 11	Develop a schedule	3.09	1.018	18
C 12	Develop a resource mgt plan	2.86	0.855	34
C 13	Establish program controls	3.00	1.057	25
C 14	Develop program plan	3.13	0.987	14
C 15	Communicate status	3.43	1.050	3
C 16	Measure performance	3.35	0.978	5
C 17	Implement corrective action	3.05	1.042	22
C 18	Implement change control	2.68	1.135	35
C 19	Respond to risk	3.12	0.943	16
C 20	Administrative closure	2.88	1.063	32
C S1	Project leadership	3.30	1.046	8
C S2	Flexibility	3.07	1.075	19
C S3	Business judgment	2.99	1.078	26
C S4	Trustworthiness	3.62	1.160	1
C S5	Communication style	3.22	1.125	11
C S6	Listening skills	3.21	1.029	12
C S7	Set and manage expectations	3.07	0.976	20
C S8	Negotiation	2.93	1.154	30
C S9	Issue and conflict resolution	3.10	1.025	17
C S10	Organizational skills	3.21	0.798	13
C S11	Coaching	2.87	1.046	33
C S12	Facilitation	2.98	0.984	28
C S13	Decision making	3.34	0.987	6
C S14	Problem solving	3.28	0.998	9
C S15	Team building	3.13	1.039	15

Note. C = Technical Skill; CS = Soft Skill

example, using this method, even though *trustworthiness* was rated of high importance, it was deemphasized in the gap analysis because it scored relatively well in the performance assessment. Conversely, the chosen method elevated *negotiation skills* to a higher gap position even though it was rated in the middle range of importance, since it was assessed near the bottom of PM performance.

Table 4 shows the top 10 competency gaps based on the Borich analysis. In this list a surprising number of technical skills topped the list, including *develop a budget, implement change control, document program constraints,* and *determine program deliverables* (Borich, 1980). Of the top 10 items, only two identified shortfalls were soft skills—*negotiation* and *team building*. These results seem contrary to assertions by Bauer (2006) and Golob (2002) that soft skills may be the most important to program

TABLE 4. COMPETENCY SHORTFALLS USING BORICH MODEL (ABRIDGED TO TOP 10)

Competency Designation	Competency	Importance (I)	Performance (P)	Difference I x (I-P)
C 9	Develop a budget	4.616	2.902	7.913
C 2	Determine program deliverables	4.753	3.268	7.060
C 18	Implement change control	4.308	2.676	7.030
C 1	Determine program goals	4.863	3.420	7.016
C 4	Document program constraints	4.466	2.978	6.643
C 11	Develop a schedule	4.527	3.088	6.519
C 13	Establish program controls	4.438	3.000	6.384
C S15	Team building	4.538	3.132	6.378
C S8	Negotiations	4.377	2.927	6.345
C 17	Implement corrective action	4.466	3.051	6.316

success, and the study by Gadeken (2004), which suggested that defense PMs should seek soft-skill training.

Conclusions

The current study appears to be the first in the literature to explore the competencies of Department of Defense program managers from the perspective of their industry counterparts. The data allowed for the ranking of competencies believed to contribute most to program success, as well as assess how well defense PMs met those competencies. From these results, a priority-ordered list was developed of competencies that are candidates for improvement through training and development. The competencies ranking in the top 10 for importance represented a relatively even mix of technical and soft skills, as did the raw rankings of PM performance. However, when analysis was done to discover the variance between competency importance and performance, the results ranked many of the technical skills at the top of the list of candidates for improvement. These findings seem to refute the conventional wisdom and may provide new insights and contributions to the literature.

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IMPROVING DEFENSE ACQUISITION DECISION MAKING

COL William R. Fast, USA (Ret.)

This research investigates evidence and tests the hypothesis that the linkages between the defense acquisition management system, the requirements process, and the budgeting system are not sufficiently defined to enable the success of acquisition programs. These disconnects contribute to weapons systems cost overruns, schedule delays, and performance problems, and are exacerbated by the ever-changing global security environment and rapid pace of technological advancement. Through historical research, qualitative and quantitative analyses, and a comprehensive review of current policies and procedures, this research illuminates these areas of disconnect and proposes specific recommendations to fix them.

Keywords: *Acquisition, Budgeting, Decision Making, Programming, Requirements*

image designed by Nina Costine »

communication reconnect

The primary purpose of this research was to investigate how well the Defense Acquisition Management System interfaces with the *requirements* and *budgeting* systems of the Department of Defense (DoD). The United States of America possesses the finest weapons systems in the world. However, the same cannot be said for the systems that enable the Pentagon to acquire those weapons systems. Cost overruns, schedule delays, and operational test failures testify to numerous severed connections among the *acquisition* management, requirements, and budgeting systems (commonly referred to as the three decision support systems). The ever-changing global security environment and the rapid pace of technological change only serve to exacerbate these problems.

For the Pentagon to earn a reputation for excellence in acquiring weapons systems, these decision support systems must operate with far better coordination and demonstrate that they can procure the right equipment, within reasonable timeframes, and at affordable prices. This research began with an investigation into the intricacies of the acquisition management, requirements, and budgeting systems. Next, interactions between these three decision support systems were illuminated to uncover areas of misalignment and disconnect. Recent initiatives to correct these problems were also identified. Finally, solutions to resolve these disconnects were enumerated.

Background

A January 2006 report of the Defense Acquisition Performance Assessment (DAPA) described the three decision support systems as:

> ...a highly complex mechanism that is fragmented in its operation. Further, the findings we developed indicated that differences in the theory and practice of acquisition, divergent values among the acquisition community, and changes in the security environment have driven the requirements, acquisition, and budget processes further apart, and have inserted significant instability into the acquisition system. In theory, new weapons systems are delivered as the result of the integrated actions of the three interdependent processes whose operations are held together by the significant efforts of the organizations, workforce, and the industrial partnerships that manage them. In practice, however, these processes and practitioners often operate independent of one another. Uncoordinated changes in each of the processes often cause unintended negative consequences that magnify the effects of disruptions in any one area.[1] (DAPA Panel, 2006, pp. 4–5)

FIGURE 1. DoD DECISION SUPPORT SYSTEMS

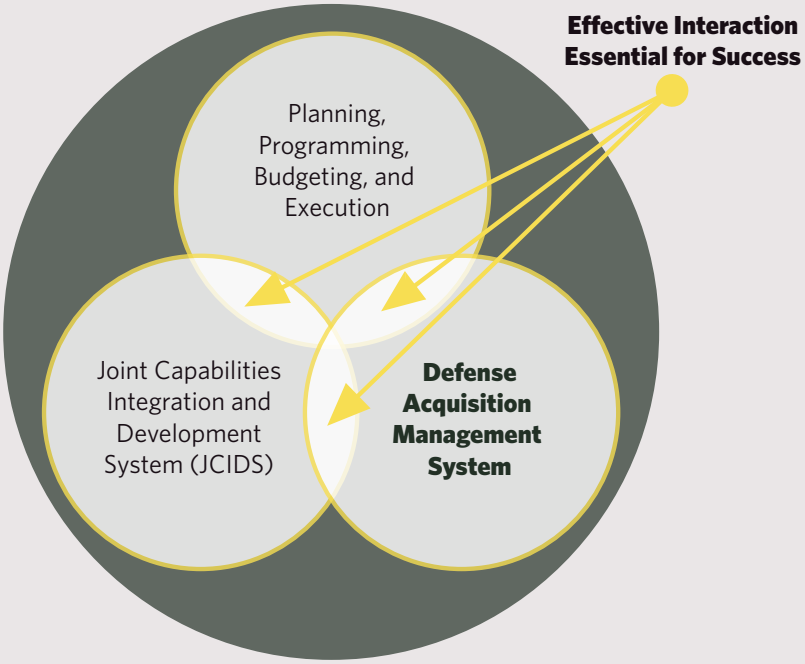
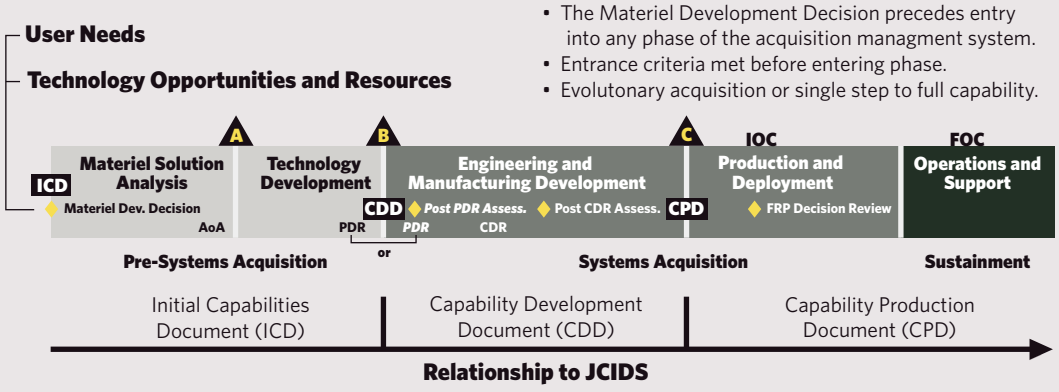


Figure 1 highlights the areas of interaction between the Defense Acquisition Management System, the Joint Capabilities Integration and Development System (JCIDS), and the Planning, Programming, Budgeting, and Execution (PPBE) system. Coordinated management decisions at these interfaces are essential for the success of any acquisition program. Thus, this research began by seeking to understand the reasons why these three decision support systems were first established and how acquisition programs are affected by the decisions made within and between these systems today.

DEFENSE ACQUISITION MANAGEMENT SYSTEM (DAMS): STRATIFIED DECISION MAKING

Decision making in today's Defense Acquisition Management System (DAMS) can be traced to 1986. The late David Packard, then president of Hewlett-Packard, was selected by Ronald Reagan to lead the President's Blue Ribbon Commission on Defense Management. Better known as the Packard Commission, its interim report of April 1986 recommended the appointment of both DoD-level and Service Acquisition Executives (SAEs). The SAEs would appoint Program Executive Officers (PEOs) under their authority that would be responsible for a manageable number of acquisition programs and project managers. By design, the chain of authority from the

FIGURE 2. THE DEFENSE ACQUISITION MANAGEMENT SYSTEM



Note. PDR=Preliminary Design Review; CDR=Critical Design Review; FRP=Full Rate Production; IOC=Initial Operating Capacity; FOC=Full Operational Capacity

project manager, through the PEO, to the SAE was short. The basic premise was that defense acquisition needed to be streamlined to run in the same manner as a commercial venture (Butrica, 2001, pp. 212–213).

Another feature of the acquisition management system is that it classifies programs for higher levels of oversight based upon expected development or production expenditures. An Acquisition Category I (ACAT I) Major Defense Acquisition Program (MDAP), requiring oversight by the Defense Acquisition Executive (DAE) or DoD Component Acquisition Executive (CAE), if so delegated, is a program that is expected to require in excess of $365 million of Research, Development, Test, and Evaluation (RDT&E) funds and/or $2.19 billion of procurement funds (in fiscal year 2000 constant dollars) (DoD, 2008a, encl. 3, p. 33).

Unlike the PPBE process that is *calendar-driven* or the JCIDS which is *needs-driven*, the acquisition management system is *event-driven*. All acquisition programs are managed through a series of sequential phases and milestone reviews (Figure 2). To successfully move from one phase to the next, a program must have demonstrated or completed the program-specific exit criteria for the current phase and must also have met the statutory and regulatory entrance criteria for the next phase. The appointed Milestone Decision Authority (MDA) makes the "go/no-go" decision based on the evidence presented at the milestone review.

The effect of having a higher level decision maker for MDAPs is that 31 percent of the department's programmed Research, Development, and Acquisition (RDA) funds are under the authority of one decision maker—the Under Secretary of Defense for Acquisition, Technology and Logistics, who is the designated DAE. Yet, the remaining 69 percent of programmed RDA

funds are under the control of the Services and Defense Agencies.[2] The total number of decision makers with MDA for lower priority acquisition programs is over 40.[3]

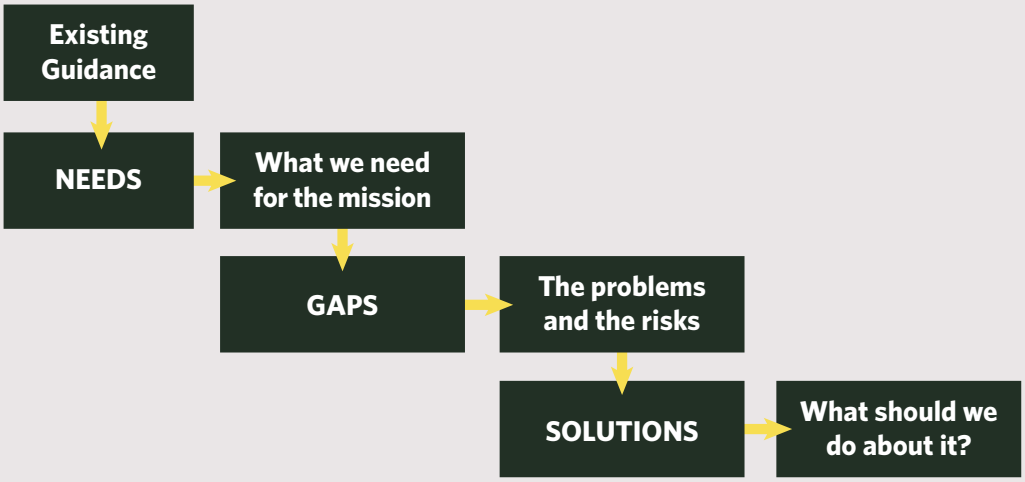
In addition, analysis of acquisition decision memoranda (ADMs) documenting the decisions of the DAE for MDAPs reveals that 36 percent of the ADMs contained language with impact on the requirements decision-making process, and 66 percent of the ADMs contained actions affecting decisions in the budgeting process.[4] Obviously, decisions made on the more numerous lower acquisition category programs also ripple into the requirements and budgeting processes at higher rates.

JCIDS: CENTRALIZING THE VALIDATION OF CAPABILITY DOCUMENTS TO ENSURE "JOINTNESS"

Historically, the military services have had their own systems for the approval of weapons systems requirements. However, in 1976 the Office of Federal Procurement Policy published Circular A-109 that required a Mission Area Analysis to determine the need for a particular weapons system (OMB, 1976). In compliance with A-109, the Services were required to perform this analysis and prepare a mission needs statement to document the need at the front end of the acquisition process (Fox, 1988, p. 46). Eventually, to ensure that requirements were not duplicated between the Services and to prompt interoperability and joint operations, the Joint Staff got involved. In the early 1990s, they required the Services to adopt a single document format for the Operational Requirements Document (ORD). In 2003, the Joint Capabilities Integration and Development System (JCIDS) process was created to identify the capabilities and associated operational performance criteria required by the joint warfighter. JCIDS also supports the statutory responsibility of the Joint Requirements Oversight Council (JROC) to validate joint warfighting requirements.

Fundamental to JCIDS is Capabilities-Based Assessment (CBA) (Figure 3). Unlike the more predictable threats of the cold war that the Pentagon could anticipate and prepare for, threats today emerge on a daily basis, and are often asymmetrical to our existing capabilities. CBA seeks to find solutions to these emerging threats by changing Doctrine, Organization, Training, Material, Leadership and Education, Personnel, and Facilities (DOTMLPF) (Chairman of the Joint Chiefs of Staff [CJCS], 2009, p. GL-3). The CBA process produces initial capability, capability development, and capability production documents (ICD, CDD, and CPD). These documents guide the technology development, engineering and manufacturing development, and production and deployment phases of the acquisition framework, respectively (Figure 2).

FIGURE 3. CAPABILITIES-BASED ASSESSMENT

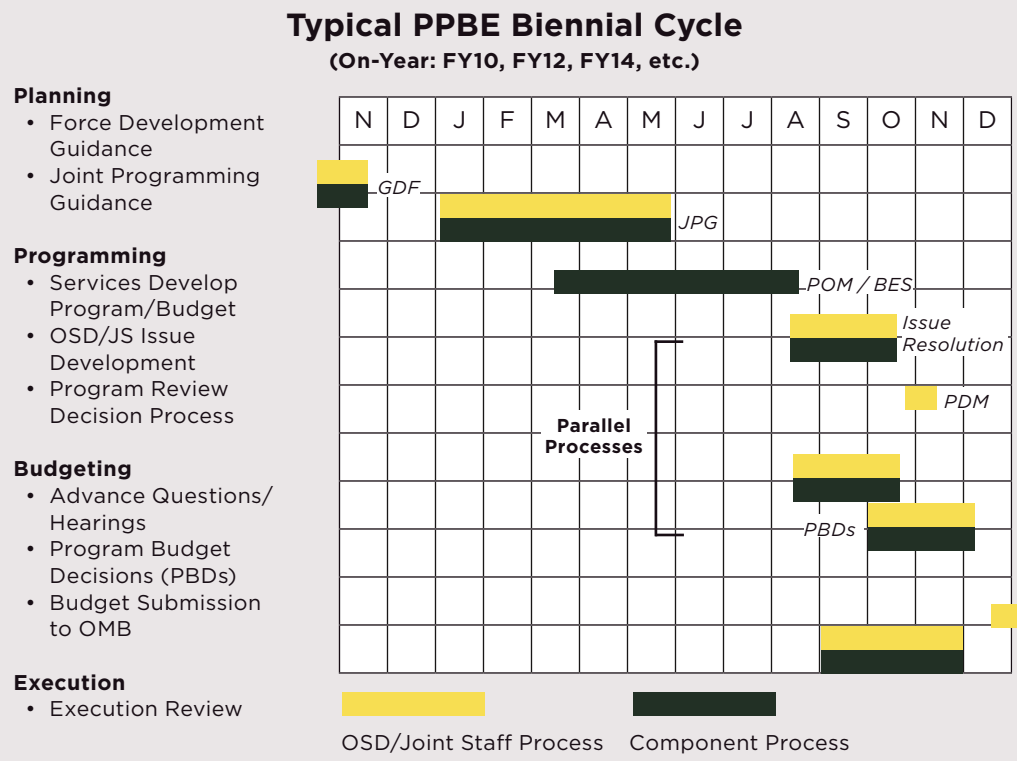


Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01G is explicit regarding how JCIDS interfaces with the two other decision support systems:

> The JCIDS process supports the acquisition process by identifying and assessing capability needs and associated performance criteria to be used as a basis for acquiring the right capabilities, including the right systems. These capability needs then serve as the basis for the development and production of systems to fill those needs. Additionally, it provides the PPBE process with affordability advice by assessing the development and production life-cycle cost. (CJCS, 2009, pp. A-1, A-2)

An approved ICD summarizes the CBA process, describes the capability gaps, and identifies potential solutions. The ICD is taken to a Materiel Development Decision (MDD) where it is reviewed and validated in order to start the acquisition process. A favorable MDD leads into the Materiel Solution Analysis phase, which is prior to Milestone A. In this phase, an Analysis of Alternatives (AoA) is prepared, based upon the broad type of materiel solution preferred in the ICD (i.e., information system, evolutionary development of an existing capability, or a transformational approach) (CJCS, 2009, p. A-3). Each alternative has an associated life-cycle cost that gives insight into the affordability of the program and provides linkage to the budgeting process. So, it is important to note that the information in the ICD drives the AoA process. The ICD also informs the technology development strategy, the test and evaluation strategy, and the

FIGURE 4. PLANNING, PROGRAMMING, BUDGETING, AND EXECUTION



systems engineering plan—all key documents for guiding the technology development phase prior to program initiation at Milestone B.

PPBE: THEN AND NOW

In the spring of 2008, the American Society of Military Comptrollers (ASMC) surveyed 575 members of the defense financial management community about the PPBE process (Figure 4). Agreement was almost universal that PPBE was the best method to link performance and budgeting, "and a strong sentiment to fully implement the system as designed" (ASMC & Grant Thornton LLP, 2008, p. 1). So, just what was PPBE originally designed to do? And, has the DoD implemented PPBE in a way that allows it to do what it was designed to do? To find answers to these questions, one must go back to the beginnings of PPBE (then PPBS) during the era of Defense Secretary Robert S. McNamara.

In 1961, President Kennedy's initial instructions to McNamara were "to determine what forces were required and to procure and support them

as economically as possible" (McNamara, 1964, p. 14). Developed by cost analysts at the RAND Corporation during the 1950s, program budgeting was just what the Pentagon needed to link budget inputs to capability outcomes and to centralize long-range planning and financial decision making under the civilian Secretary of Defense. The system was originally called the Planning, Programming, and Budgeting System (PPBS), and its fundamental purpose was to unify annual budgets and nonfinancial longer range planning. In the age of the nuclear bomb, the task of long-range planning was to calculate the needed effects or outputs that had to be produced by military forces and weapons systems in order to prevail. Budgeted funds for these military forces and weapons systems came from the funding appropriations for military personnel, research and development, procurement, and operations and maintenance. Yet, budgets are resource inputs. Moreover, because of the long development cycles for modern weapons systems, annual budgeting was not a useful planning tool. The key for McNamara, and the objective of PPBS, was to link the planning outputs to the appropriated funds inputs through the construct of defined program elements within a 5-year force structure and financial program (Novick, 1962, p. 2).

As originally envisioned, planning within the PPBS was to be a comparative analysis of the projected costs and effectiveness of feasible alternatives. The example used by David Novick, one of the developers of program budgeting, is the comparison of the merits of buying more Polaris submarines versus Minuteman missile squadrons. Both systems could deliver nuclear warheads. The comparison between the two alternatives involved the methodical examination of the cost estimates for manpower, equipment, and facilities, and the expected military benefits (capability outcomes) derived from the systems (Novick, 1962, p. 6). Today, comparatively little analysis to this level of detail takes place in the planning phase of PPBE. Up until 2006, planning was simply an effort to turn the National Security Strategy (NSS), National Defense Strategy (NDS), National Military Strategy (NMS), and the Quadrennial Defense Review (QDR) into guidance from which the Services could develop their Program Objective Memoranda (POMs). Such a shallow planning effort resulted in guidance that was not specific enough, in terms of priorities and quantities, for the *programming* of adequate resources for weapons systems acquisitions. Here is but one of many examples.

The *National Security Strategy* (Clinton, 2000) was silent on the role of the military in finding and taking the fight to terrorists. While the document discusses the need for the military to help deter terrorism and respond in retribution to terrorist attacks, the mission of finding and destroying terrorist organizations is not mentioned. Thus, the FYDP for fiscal years 2002-2007, prepared by the Pentagon in fiscal year 2000, lacked a vision for the weapons systems and equipment necessary to prosecute an offensive global war on terror (Paparone, 2008, p. 157).[5] As the world changes at an

unprecedented pace, casting a meaningful strategic vision becomes more and more problematic. Without meaningful strategic vision, the acquisition management system may continue to acquire programs that will no longer be needed—and may fail to start programs that will be needed. The Obama Administration has yet to set clear national security priorities. As a result, the Pentagon began in early 2009 the planning phase for fiscal years 2012-2017 without the benefit of an NSS. Clearly, no one knows what the future will hold. However, planning for a future we cannot see and attempting to bring that illusion to the future fight, with all the associated weapons systems acquisition requirements, is clearly folly if not patently dangerous. Yet, this is the current planning process upon which the Pentagon justifies and builds its 6-year defense program.

The Government Performance and Results Act (GPRA) of 1993 requires that each government agency establish a results-oriented management approach to strategically allocate resources on the basis of performance (GPRA, 1993). In assessing the implementation of GPRA, the Government Accountability Office has criticized the DoD for not establishing goals or timelines for accountability and for the measurement of progress toward implementation. DoD implemented a risk management framework in its strategic plan—the 2001 QDR report (GAO, 2005, p. 8). However, it was not until 2003 that the DoD adopted the balanced scorecard approach to implement risk management. The GAO criticized the DoD for not integrating this framework with other decision-making support processes. Specifically, the GAO said that to be effective, risk-based and results-oriented management approaches have to be integrated into the usual cycle of agency decision making. The GAO presumed that without this level of integration, a mismatch between programs and budgets would continue, and a proportional rather than strategic allocation of resources would go to the Services.[6] In addition, the Congress would not have insight as to the risks and trade-offs made during the Pentagon's investment decision making (GAO, 2005, p. 5).

Chartered to examine how DoD develops, resources, and provides joint capabilities, the Joint Capabilities Study Team (also called the Aldridge Study) reported these findings to Defense Secretary Rumsfeld in 2004: "Services dominate the current requirements process…; Service planning does not consider the full range of solutions available to meet joint warfighting needs…; and, the resourcing function focuses senior leadership effort on fixing problems at the end of the process, rather than being involved early in the planning process." They also found that programming guidance exceeds available resources (DoD, 2004, p.iii). Others have also identified this programming guidance "gap" (Christie, 2008, p. 196; Church & Warner, 2009, p. 82; Johnson, 2003, p. 9).

The Aldridge Study proposed a four-step process: strategy, enhanced planning, resourcing, and execution and accountability. The strategy step involved the combatant commanders and answered the question: "What to

do?" The enhanced planning and resourcing steps answered the question: "How to do it?" The execution and accountability step answered the question: "How well did we do?" Formal process review points for the Secretary of Defense were proposed after each of the four steps (DoD, 2004, p. v).

Many of the recommendations from the Aldridge Study were implemented. Most notably, the Enhanced Planning Process (EPP) was made a phase of the Strategic Planning Process, and the EPP is to be approved by the Secretary or Deputy Secretary of Defense. Moreover, the Joint Programming Guidance is to document the decisions resulting from the EPP phase (DoD, 2006, p. 2). The Director of Program Analysis and Evaluation (PA&E) already had responsibility as the Office of the Secretary of Defense (OSD) lead for coordinating the program review of the PPBE process. The only problem with this new assignment is that it appears to conflict with the responsibilities of the Under Secretary of Defense (Policy), who has overall responsibility for coordinating the PPBE planning phase (DoD, 2003, p.5).

Another problem for PPBE is that developing and finally enacting the first year of the 6-year program takes a long time. The program (termed *Future Years Defense Program* or *FYDP*) is put together only once every 2 years, during even numbered years. For example, in calendar year 2010, the Pentagon will put together the 6-year program for fiscal years (FY) 2012 through 2017. However, the Services began working on their portions of that FY2012–2017 program in the middle of calendar year 2009—more than 3 years before the first year funds for FY 2012 will be appropriated by the Congress. The next opportunity to make major changes to the program is in calendar year 2012 when the program for FY 2014-2019 will be accepted by the Pentagon. Changes to the program are possible during the odd numbered years. However, these changes are usually limited to necessary fact-of-life adjustments. New starts (or stops) are generally not considered in the odd numbered years. Thus, the programming phase of the PPBE process suffers from *false precision*. Even if the vision of the future was correctly identified in the planning phase, programming for weapons systems new starts can only be done every other year. Moreover, funds requested are for use more than three or more years hence. Inevitably, projections for weapons systems costs that far in advance of execution are bound to be flawed. Yet, the process demands precision, whether or not that precision has any meaning (McCaffery & Jones, 2005, p. 159).

As originally envisioned, Secretary McNamara expected to conduct a continuous review of the entire defense program. In other words, he expected to have an up-to-date 5-year force structure and financial program at all times. McNamara's PPBS had a program change control system in which variations from approved cost estimates required advance authorization. Standard forms were established for research and development, investment, and operations—each relating to the key decision

points in the life of a weapon system. The program change control system was first applied to 200 of the most important material systems. Milestone schedules were prepared for these systems, and actual progress was reported on a monthly basis, including the need for corrective action or revision to the financial plan (Novick, 1962, pp. 7–10). Such is not the case today. The FYDP is open for changes only twice a year—in August when POMs (or changes to the previous POMs) are submitted by the Services to OSD, and at the end of the combined program and budget review once resource management decisions have been made and the defense budget is finalized for the Office of Management and Budget.

In his first year as Defense Secretary, McNamara was heavily involved in the cost-effectiveness and requirements studies of the planning phase of PPBS. Known as "McNamara's 100 Trombones," he assigned about 100 requirements projects to the Joint Chiefs of Staff, the Services, and various elements of OSD. These planning studies were truly participative in nature and required a significant time commitment from McNamara, but they resulted in detailed acquisition programming guidance for the Services. For example, in his first year McNamara made decisions on the number of strategic missiles and bombers for the next decade. He also decided on the airlift and sealift needed to support contingency war plans and the most cost-effective way of replacing worn out ground equipment for the Army (Hitch, 1965, pp. 74–75).

Senior leader involvement in today's PPBE process has typically been toward the end of the programming phase rather than in the earlier planning phase. This is not the optimum time for these senior leaders to enter the PPBE decision-making process. Moreover, failing to make the tough decisions up front in the planning phase only delays them into late in the programming phase (Johnson, 2003, pp. 10–11). Decisions become harder to make during the final stages of programming because less discretionary funding is available, and earlier decisions will need to be reconsidered. Such late decision making on weapons systems acquisition terminations was typical in past PPBE cycles. However, as demonstrated by Defense Secretary Gates during the 2010 budget deliberations, he may get more involved up front and make these types of decisions early in the planning phase of PPBE.

Today, PPBE fiscal and programming guidance is usually late in arriving to the Services. While no directive or instruction establishes a date for issuance of fiscal/programming guidance, issuance dates for the past two PPBE cycles were March 14, 2008, for POM 10-15; and May 7, 2009, for POM 11-15. Fiscal guidance refers to the total obligation authority, by fiscal year, available to the Services. Fiscal/programming guidance is used by the Services to develop their POMs, or changes to the previous POM, which are usually due in August. They begin development of their POMs in the last few months of the prior year (October–December timeframe). While draft fiscal/programming guidance is often released earlier, final fiscal/programming

guidance is usually issued too late to be useful. Today, fiscal/programming guidance is found in the "fiscally informed" Guidance for the Development of the Force (GDF) and the "fiscally constrained" Joint Programming Guidance (JPG) (Church & Warner, 2009, p. 84). The predecessor to the GDF was the Strategic Planning Guidance (SPG), and before the SPG, the Defense Planning Guidance (DPG). Originally envisioned to align strategy with investments, the GDF appears to have become a "wish list of programs and priorities for every constituency." Feedback from the Services on the usefulness of the GDF and JPG is mixed. As indicated, both documents, but especially the JPG, are issued well after the Services have completed the development of their POMs and decisions made to fund or not fund various weapons systems programs (Church & Warner, 2009, pp. 81-82).

Understandably, and working at a disadvantage with unclear programming guidance, the Service POMs are invariably criticized for failing to comply with the GDF/JPG. In addition, the POMs are faulted for underestimating technology risks associated with weapons systems investments (Christie, 2008, p. 212). As a result, the Services tend to *over program*, believing they can develop, produce, and place in operation many more programs than realistically possible (Christie, 2008, p. 196; Church & Warner, 2009, p. 82). In other words, their 6-year programs fail to consider the cost "tails" past the last year of the FYDP. This is particularly a problem with weapons systems production programs that build up to an unrealistically high "bow wave" of procurement funding beyond the FYDP that becomes unaffordable for the Service and DoD.

Per DoD Directive 7045.14, the official linkage between the PPBE and acquisition management systems is achieved by *designated membership* on the Defense Systems Acquisition Review Council (now the Defense Acquisition Board [DAB]), the Defense Resources Board (now the Deputy's Advisory Working Group [DAWG]), and the Senior Leader Review Group (SLRG); and the requirement to develop an acquisition strategy for all major systems (DoD, 1984, reissued 1987, p. 6). The DAB is chaired by the Under Secretary of Defense for Acquisition, Technology and Logistics, who is also a member of the SLRG and DAWG. The SLRG is chaired by the Secretary of Defense, and the DAWG is chaired by the Deputy Secretary of Defense, neither of whom sits on the DAB. In total, 11 senior leaders are members of both the DAB and the SLRG/DAWG.[7] The average tenure of the DAE is just 24 months.[8] Most MDAPs have development cycles that exceed the tenure of four or even five DAEs. Therefore, the effectiveness of having senior leaders serve as the linkage between the resourcing and acquisition management systems might be questioned, given their enormous responsibilities and brief tenures serving as the DAE. Certainly, 11 senior leaders cannot be held responsible for coordinating the multitude of interactions between the acquisition and budgeting systems.

Recommendations

In 1979, the Defense Resource Management Study (DRMS) recommended to President Carter that the programming and budgeting phases of PPBE be combined into a single annual review. The DRMS also recommended that the time freed up by combining the two phases be used to "focus additional attention on the strategic and resource planning issues, including resolution of selected major issues prior to the program/budget review" (Rice, 1979, p. viii). This was the centerpiece of the DRMS proposal, and it was designed to open up a "broad planning window" that would include "an orchestrated OSD review and prioritization of the Defense Systems Acquisition Review Council-approved programs competing for segments of the planning wedge" (Rice, 1979, pp. 9, 16). These recommendations were not implemented. However, in 2003, Defense Secretary Rumsfeld did combine programming and budgeting phases, but not with the intention of freeing up time for better planning. Rather, Rumsfeld's Management Initiative Decision 913 specified that the freed up time would be used for an execution review (i.e., the new "E" in PPBE) to "make assessments concerning current and previous resource allocations and whether the department achieved its planned performance goals" (DoD, 2003, p. 7; Church & Warner, 2009, p. 81; Dawe & Jones, 2005, p. 49; Jones & McCaffery, 2005, p. 90). The Pentagon has yet to institutionalize this execution review. A recent survey of 575 professionals in the defense finance and accounting community found that, due to the wartime supplemental funding for operations in Iraq and Afghanistan, emphasis on execution had not made the relationship between budget execution and performance more visible, nor had it provided the data needed to make more timely decisions to improve the PPBE process (ASMC & Grant Thornton LLP, 2008, pp. 5-7). Perhaps, the "broad planning window" recommendation of the DRMS should again be considered, and this time implemented, to help resolve and clarify competing requirements and acquisition programs before the Services have to prepare their POMs.

In 2007, Capability Portfolio Management was introduced to the programming phase of PPBE. The official definition of Capability Portfolio Management is "the process of integrating, synchronizing, and coordinating DoD capabilities needs with current and planned DOTMLPF investments within a capability portfolio to better inform decision making and optimize defense resources" (DoD, 2008c, p. 8). The Capability Portfolio Management initiative seeks to place all current and proposed warfighting needs into logical, manageable functional categories. In an effort to minimize redundant capabilities, capability portfolios are joint, not Service-specific. Capability Portfolio Managers (CPMs) provide cross-Component alternatives and recommendations on current and future capability needs and investments. They are to work with the JROC and the JCIDS, and

develop capability planning guidance for inclusion in the GDF. Therefore, CPMs can impact capability portfolio composition, weapons systems acquisition, and weapons systems sustainment choices. In retrospect, the job of the CPMs is similar to the system analysts of the McNamara era. The systems analysts prepared "cost-effectiveness studies" and "requirements studies" at the request of the Secretary of Defense and the Joint Chiefs of Staff (Hitch, 1965, pp. 73-75). However, the advice of current day CPMs is officially sought only at the end of the programming phase of PPBE when they provide the DAWG with independent programmatic recommendations and cross-Component perspectives on planned and proposed capability investments (DoD, 2008c, p. 6). To have greatest influence, decision makers need to formally tap into the advice of these CPMs about 9 to 12 months earlier, during the planning phase of the PPBE process.

The deliberate, evolutionary pace of the cold war is long past. The challenges of an ever changing global security environment and the rapid pace of technological advancement represent a national imperative for the Pentagon to seek out and cultivate breakthrough ideas in the development and employment of defense systems (Johnson, 2003, pp. 6-7). To meet these challenges, the PPBE planning phase should be revitalized and extended to allow time for brainstorming and germination of innovative ideas, and for the analysis of the costs and effectiveness of various weapons systems alternatives.

Conclusions

As implemented today, the PPBE process is far different from the PPBS established by Secretary of Defense McNamara in 1961. Over the course of nearly 50 years, changes have severely de-emphasized decision making in the planning phase. As a result, the department has had to establish a separate requirements analysis and approval system. The concept behind today's JCIDS was actually part of McNamara's long-range planning to determine the most cost-effective capability outcomes. Likewise, in McNamara's management system, weapons systems development and production decisions, along with necessary funding adjustments, were made in real time, and at the same time as requirements decisions. Today, the linkage between PPBE and weapons systems decisions suffers from the timing disconnect between a calendar-driven budget and event-driven acquisition programs. To improve acquisition decision making, the linkages between the requirements, budgeting, and acquisition decision-making systems must be reestablished. One solution is to reinvigorate the planning phase of PPBE and make the necessary decisions on weapons systems requirements, multiyear budgeting, and acquisition program continuation or termination, within the timeframe of that phase.

Author Biography

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ENDNOTES

1. This problem has not been fixed. Writing in the January/February 2009 issue of *Foreign Affairs*, Secretary of Defense Robert M. Gates (2009) called for a reassessment of priorities within the Department of Defense:

> The defining principle of the Pentagon's new National Defense Strategy is balance. The United States cannot expect to eliminate national security risks through higher defense budgets, to do everything and buy everything. The Department of Defense must set priorities and consider inescapable tradeoffs and opportunity costs.
>
> The strategy strives for balance in three areas: between trying to prevail in current conflicts and preparing for other contingencies, between institutionalizing capabilities such as counterinsurgency and foreign military assistance and maintaining the United States' existing conventional and strategic technological edge against other military forces, and between retaining those cultural traits that have made the U.S. armed forces successful and shedding those that hamper their ability to do what needs to be done. (p. 28).

   How Gates will achieve this rebalancing of priorities is the essence of this research.
2. In Future Years Defense Program 2008–2013 (FYDP 2008–2013), the total obligation authority for RDT&E and Procurement was $1,154 billion. By virtue of the fact that the Under Secretary of Defense for Acquisition, Technology and Logistics is the MDA for MDAPs, the OSD has control over acquisition decisions totaling $362 billion, or about 31 percent of the total obligation authority in FYDP 08-13. On the other hand, the Services make decisions on about $792 billion, or about 69 percent of the total obligation authority for RDT&E and procurement in FYDP 08-13 (DoD, 2008d, Table 1-9, p. 13; DAMIR, n.d., MDAP/MAIS Selected Acquisition Report query, FYDP 08-13).
3. Each Service and Defense Agency has an Acquisition Executive (AE) with MDA. In addition, all PEOs have MDA. The total number of PEOs is 35 (Army-11; Navy-13; Air Force-11). (Source: Organizational charts of Army, Navy, and Air Force AEs. Retrieved November 14, 2009, from https://www.alt.army.mil/portal/page/portal/oasaalt, https://acquisition.navy.mil/rda/content/view/full/4539, http://ww3.safaq.hq.af.mil/organizations/index.asp)
4. The Defense Acquisition Management System (DAMS) uses ADMs as records of the decision made by the AE. For purposes of this research, ADMs for the following weapons systems were reviewed: Expeditionary Fighting Vehicle (6 ADMs); Future Combat System (10 ADMs); Global Hawk (12 ADMs); Joint Strike Fighter (13 ADMs); and Littoral Combat Ship (3 ADMs). In total, 44 ADMs were reviewed. Of these, 36 percent (16 ADMs) contained actions that would require involvement of the JCIDS. In addition, 66 percent (29 ADMs) contained actions that would impact upon the PPBE process (ADM, n.d.).
5. COL Christopher R. Paparone, USA (Ret.), makes an argument that the *Joint Vision 2020*, published in June 2000, focused on defensive force protection from terrorists, not on the use of military forces to combat terrorism in an offensive way, which was the case after September 11, 2001. While the *Joint Vision 2020* was not a PPBE document, per se, his point is applicable. Combating terrorists offensively is not seen in the National Security Strategy prior to 9/11. This is not the only failure on the part of past Presidential Administrations in providing meaningful strategic priorities. The *2002 National Security Strategy (NSS)* failed to envision the invasion of Iraq on March 20, 2003, the fall of Baghdad, and the associated requirements for nation building that were thrust onto the military. The *2004 National Military Strategy (NMS)* failed to envision the need for massive humanitarian aid in the wake of the Indian Ocean tsunami of December 24, 2004, and the associated requirements that the military would need for logistical

support across the shores of devastated islands and coastal regions. Similarly, the *2005 National Defense Strategy (NDS)* failed to envision that North Korea would test fire missiles over the Sea of Japan on July 4, 2006, and subsequently explode a nuclear device in the mountains on October 9, 2006. The 2005 NDS makes no mention of our nation's need to acquire an integrated missile defense capability.

6. The Government Accountability Office says that even though the DoD has adopted a risk management planning framework and balanced scorecard approach to programming for outcomes, the percentage of total obligation authority in the FYDP, by Service, has remained relatively unchanged. The GAO provided the following figures in its report, *Defense Management: Additional Actions Needed to Enhance DoD's Risk-based Approach for Making Resource Decisions* (GAO-06-13):

TABLE. MILITARY SERVICE AND DEFENSE-WIDE PERCENTAGE OF THE 2005 AND 2006 FUTURE YEARS DEFENSE PROGRAMS

	2005 Percentage of FYDP	2006 Percentage of FYDP	Percentage Change by Department
Department of the Army	24.23	24.63	0.40
Department of the Navy	29.75	29.47	-0.28
Department of the Air Force	29.80	29.82	0.02
Defense-wide	16.22	16.08	-0.14
Total	100.00	100.00	

(Source: GAO, 2005, p. 16)

7. The members of both the DAB and the SLRG/DAWG are: Under Secretary of Defense for Acquisition, Technology and Logistics; Vice Chairman of the Joint Chiefs of Staff; Secretaries of the Military Departments; Under Secretary of Defense (Policy); Under Secretary of Defense (Comptroller); Under Secretary of Defense (Personnel and Readiness); Under Secretary of Defense (Intelligence); Assistant Secretary of Defense for Networks and Information Integration/DoD Chief Information Officer; Director, Cost Assessment and Program Evaluation (DoD, 2008b, encls. 3 & 4; DoD, 2009, p. 10.2.1).
8. From Richard Godwin, the first Under Secretary of Defense (Acquisition) until Ashton Carter, the current Under Secretary of Defense for Acquisition, Technology and Logistics, average tenure has been 24 months. To date, the shortest service was by Godwin who served 12 months (September 1986–September 1987), and the longest service was by Jacques Gansler, who served 38 months (November 1997–January 2001) (Brown, 2005).

APPENDIX

List of Abbreviations and Acronyms

ACAT	Acquisition Category
ADM	Acquisition Decision Memorandum or Acquisition Decision Memoranda
AE	Acquisition Executive
AoA	Analysis of Alternatives
ASMC	American Society of Military Comptrollers
BES	Budget Estimate Submission
CAE	Component Acquisition Executive
CBA	Capabilities-Based Assessment
CDD	Capability Development Document
CDR	Critical Design Review
CJCS	Chairman of the Joint Chiefs of Staff
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CPM	Capability Portfolio Manager
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DAMS	Defense Acquisition Management System
DAPA	Defense Acquisition Performance Assessment
DAWG	Deputy's Advisory Working Group
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DOTMLPF	Doctrine, Organization, Training, Material, Leadership and Education, Personnel, and Facilities
DPG	Defense Planning Guidance
DRMS	Defense Resource Management Study
encl.	enclosure
EPP	Enhanced Planning Process
FRP	Full Rate Production
FY	Fiscal Year
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GDF	Guidance for the Development of the Force
GPRA	Government Performance and Results Act
ICD	Initial Capabilities Document
JCIDS	Joint Capabilities Integration and Development System
JPG	Joint Planning Guidance
JROC	Joint Requirements Oversight Council
JS	Joint Staff
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program

NDS	National Defense Strategy
NMS	National Military Strategy
NSS	National Security Strategy
OMB	Office of Management and Budget
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
PA&E	Program Analysis and Evaluation
PBD	Program Budget Decision
PDM	Program Decision Memorandum
PDR	Preliminary Design Review
PEO	Program Executive Office or Program Executive Officer
POM	Program Objective Memorandum or Program Objective Memoranda
PPBE	Planning, Programming, Budget, and Execution
PPBS	Planning, Programming, and Budgeting System
QDR	Quadrennial Defense Review
RDA	Research, Development, and Acquisition
RDT&E	Research, Development, Test, and Evaluation
SAE	Service Acquisition Executive
SLRG	Senior Leader Review Group
SPG	Strategic Planning Guidance

IT'S TIME TO TAKE THE CHILL OUT OF COST CONTAINMENT AND RE-ENERGIZE A KEY ACQUISITION PRACTICE

Col Robert L. Tremaine, USAF (Ret.) and Donna J. Seligman

Unless program managers (PM) tackle cost containment head-on, future weapon system acquisition successes may be jeopardized, resulting in fewer products and services to equip the nation's warfighters. The United States can ill afford any decrease in its preparedness when the nation is currently waging war on two fronts. This research examines cost containment in the context of Total Life Cycle Cost Management. A more thorough understanding and aggressive application of cost-containment strategies could conceivably shift acquisition outcomes to a more cost-effective posture. Responding to a survey conducted as part of this research, 887 Department of Defense (DoD) acquisition professionals provided input on cost containment, including tool types and associated processes. Of those 887 respondents, 543 were current or former DoD PMs.

Keywords: *Life Cycle Cost Management (LCCM), Cost Containment, Cost as an Independent Variable (CAIV), Performance Based Logistics (PBL), Cost Analysis Requirements Description (CARD), Earned Value Management (EVM), Technology Readiness Level (TRL)*

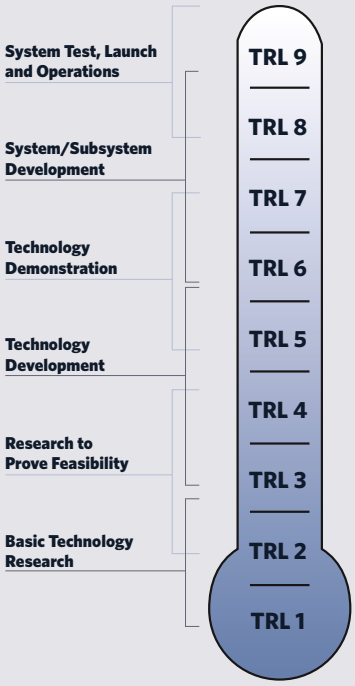
image designed by Harambee Dennis »

Materiel Solution Analysis
A
Technology Development
B
Engineering and Manufacturing Development
C
Production & Deployment
Operations & Support

Is there a superior acquisition development decision aid that can assure more program successes and help contain costs? Interestingly enough, some of the most basic tools currently at our disposal in the Department of Defense (DoD) are already ideally suited to help achieve acquisition excellence. They can also have a significant impact on fiscal outcomes. For some time, program managers (PMs) have had access to these in the form of a customized Tool Kit that outlines and characterizes a wide array of helpful decision aids and measures (Defense Acquisition University [DAU], 2009a), including:

- *Technology Readiness Level (TRL)*. Tempers technology insertion by measuring technology maturity; ensures technology properly finds its way into development efforts, while accounting for any associated risks; and considers performance and life-cycle factors before a technology solution is finalized (Figure 1)

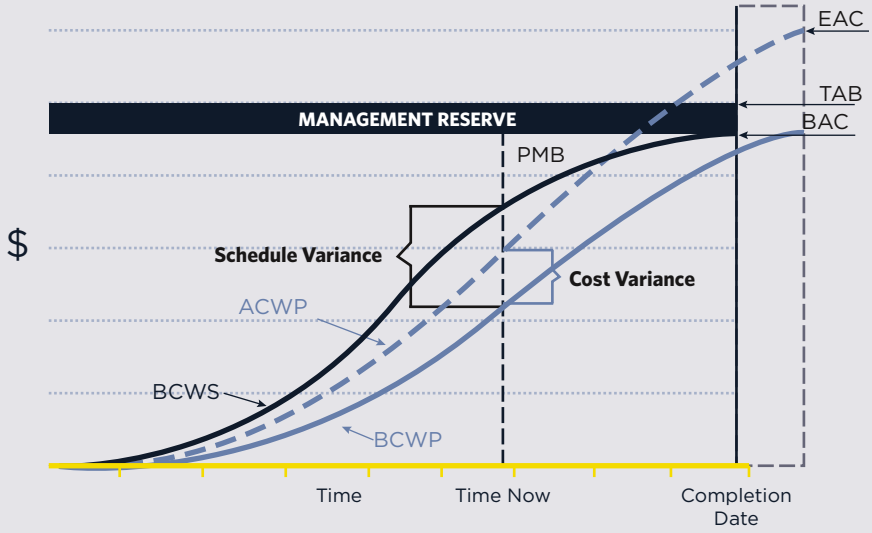
FIGURE 1. TECHNOLOGY READINESS LEVEL SCALE



(Source: Labay, 2009)

- *Earned Value Management (EVM)*. Predicts cost and schedule perturbations, provides early warning, and serves as a forecasting tool that ties itself to traceable physical work packages (under an overall Work Breakdown Structure [WBS]) (Figure 2)

FIGURE 2. EARNED VALUE MANAGEMENT (EVM) GRAPH



Note. BCWS=Budgeted Cost For Work Scheduled; BCWP=Budgeted Cost for Work Performed; ACWP=Actual Cost of Work Performed; EAC=Estimate At Completion; TAB=Total Allocated Budget; BAC=Budget At Completion
(Source: DAU, 2009b)

FIGURE 3. COST ANALYSIS REQUIREMENTS DESCRIPTION (CARD)

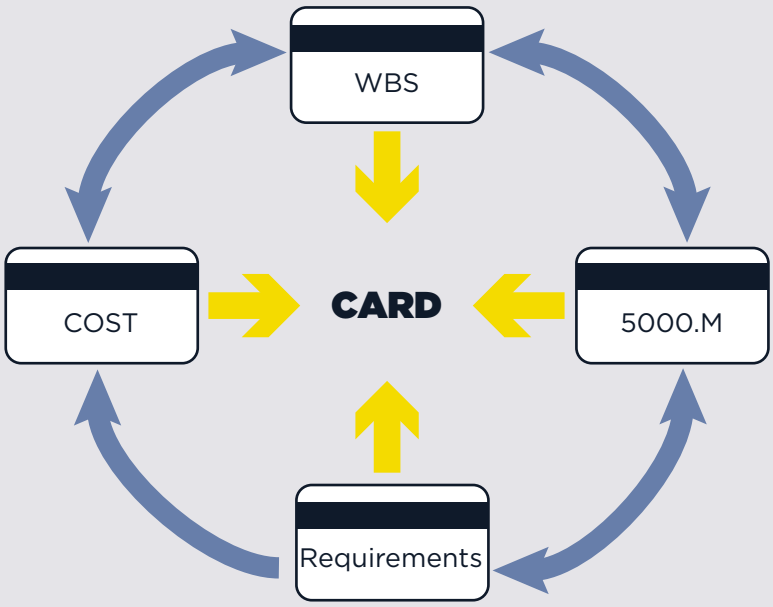


FIGURE 4. TECHNICAL AND MANAGEMENT PROCESSES

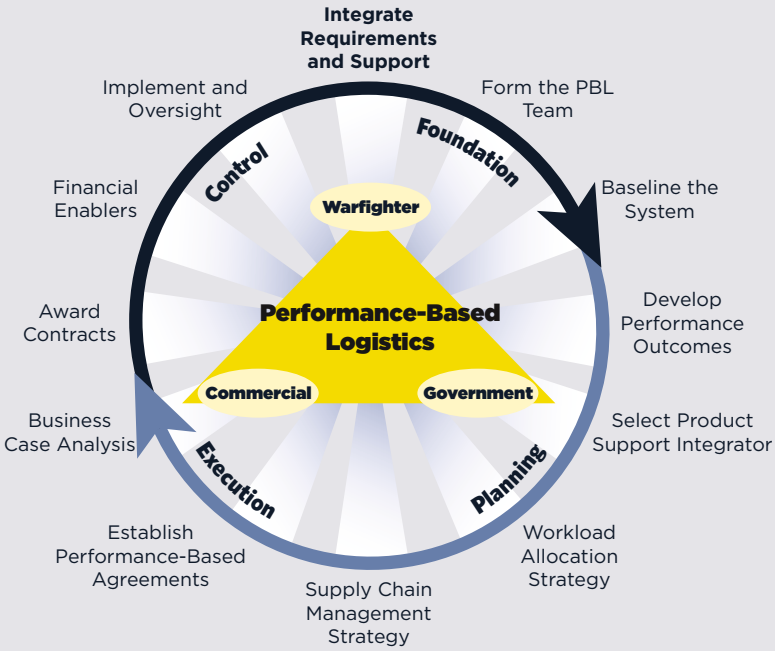
Technical Processes	Technical Management Processes
Top-Down Processes (include requirements development, logical analysis, and design solution)	Technical Planning
	Technical Assessment
Bottom-Up Realization Processes (include implementation, integration, verification, validation, and transition)	Decision Analysis
	Technical Control Processes (include requirements management, risk management, configuration management, and technical data management)

(Source: Tremaine, 2009)

- *Cost Analysis Requirements Description (CARD)*. Provides comprehensive and detailed descriptions of acquisition programs; supports Program Office Estimates (POE), Component Cost Analyses (CCA), and independent Life Cycle Cost Estimates (LCCE) (Figure 3)
- Technical and Management Processes. Ensure products properly evolve from concept to deployment; set the stage for the selection of a wide range of alternative design approaches through an integrated superset of design, assessment, and control processes (Figure 4)
- *Performance-Based Logistics (PBL)*. "Provides a means for the resource-constrained program management office to develop, implement, and manage the sustainment of a system over its life cycle" (Fowler, 2009) (Figure 5)
- *Cost as an Independent Variable (CAIV)*. Weighs affordable performance capabilities and scheduling based on cost goals that can be realized by a set of decisions that balances programmatic risks (Rush, 1997). Also serves as a trade-off tool to achieve Reduced Total Ownership Costs (Pallas & Novak, 2000) (Figure 6).

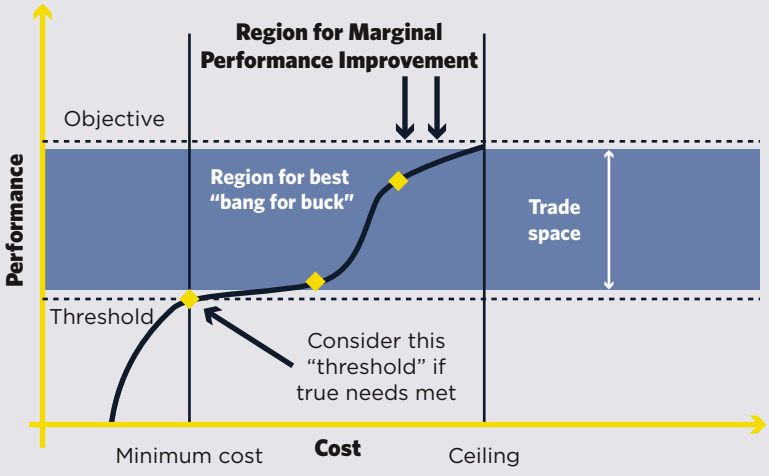
Taken together, these tools can give PMs the power to overcome many of the looming programmatic hurdles that continue to surface as often as the weather changes. Many other helpful decision aids are available and designed specifically to combat the challenges PMs face every day. Considering this wide and diverse array of decision aids, what is missing? What have we actually failed to characterize that ostensibly

FIGURE 5. PERFORMANCE-BASED LOGISTICS 12-STEP PROCESS MODEL



(Source: PBL, n.d.)

FIGURE 6. CAIV FOCUSES ON THE "KNEE OF THE CURVE"



(Source: Criscimagna, n.d.)

fuels cost growth? Why do examples keep surfacing like the MV-22 Osprey, where costs per flight hour—currently at $11,000—are expected to more than double the target estimate (Clark, 2009)? If so many variable costs can fluctuate, can they be properly tracked and addressed in time to contain costs?

One methodology in particular was expected to give truthful predictions of total costs. But, its value has presumably diminished in the face of the very dynamic and complex processes normally associated with acquisition programs in the DoD. It goes by the name *Life Cycle Cost Management (LCCM)*. Up to now, it has been used to understand both the wide array of system costs that start with a program's initial baseline and run all the way through disposal.

Discussion

Conceptually, LCCM is not new. As early as 1936, T. P. Wright had already created cost estimating equations to predict the cost of airplanes over long production runs (Hamaker, 1994). Oddly enough, many are still in use today. In varying degrees, support for LCCM continued to grow ever since. In 1975, an Air Force working group recommended five required actions to effectively institute LCCM capabilities in program offices. They recommended:

- Program offices be provided with a source of personnel familiar with analytical techniques
- Engineers and analysts be given general guidance on how to develop, adapt, and use life-cycle cost models for specific applications
- Program office and supporting personnel have access to a short course in the subject of development and application of LCC models and methods
- Periodic life-cycle cost methods workshops be held
- Program office personnel be provided with a central focus of expertise where lessons learned in each new life-cycle application are integrated with existing LCC models and methods (McKenzie, 1978).

LCCM is certainly not an underdeveloped concept, either. Over the years, a number of LCC models have surfaced to help programs fashion their overall funding profiles. Each model takes into account the broad range of a system's true costs, including its economic life, inflation rates, discount rates, total number of cost elements that comprise the system, magnitude of cost elements, and salvage value, etc. But to this day, when asked about their experience with LCC models, their applicability, usefulness, ease of

TABLE 1. VALUE OF LIFE CYCLE COST MANAGEMENT: VIEWS OF ACAT I PROGRAM MANAGERS

	ACAT I Program Managers with over 11 years of experience			
	No Experience with Model	Thoughts based on Experience with Model		
LCCM Models	Not Familiar or Not Used	Not Useful	Useful	One of the Best
ACARA	87%	2%	10%	1%
CASA	78%	2%	18%	2%
EDCAS	90%	2%	7%	1%
MAAP	89%	2%	7%	2%
FLEX	91%	3%	4%	2%
LCCA	72%	3%	22%	4%
LCCH	74%	2%	21%	3%
PRICE	73%	2%	23%	3%
ZCORE	92%	2%	3%	0%
ACEIT	70%	2%	24%	4%

Note. This table represents an opinion survey conducted for purposes of this research; the percentages represent input from 887 survey respondents, 543 of whom were current or former DoD PMs.

use, and limitations are viewed as questionable by many, including DoD's most experienced program managers (Table 1). Confidence in these models appears to have waned.

Sentiments like those expressed by the National Aeronautics and Space Administration (NASA, 2008) are common among many acquisition professionals with comparable years of experience on the subject of developing/relying upon the accuracy of LCC estimates that models like these provide.

> It involves using incomplete, inaccurate, and changing data for an outmoded & ineffective space system to derive the precise cost of purchasing an unknown quantity of an undefined new space system to satisfy an overly exaggerated and unvalidated requirement at some time in the future, under uncertain conditions, with a minimum of funds. (p. 17)

Whatever model or methodology is selected, carefully (and frequently) applying it can have a lasting effect on *cost containment*. Of

primary importance is the selection of the most suitable LCC model(s). Each characterizes a number of important variables a little differently. Nonetheless, each LCC model also has the capacity to magnify cost drivers, early and often. Regrettably, Booz Allen-Hamilton reported that the "real issue is one of obtaining the data in a timely manner and of reducing the redundant data collection effort needed every time a cost-effectiveness question arises in the decision-making arena" (Leggitt, 1981, p. 13). However, unless PMs alter their views on their usefulness and frequency of use, these models/methodologies will likely have less influence on key decisions.

Fundamentally, LCCM is actually an extraordinary concept, which is generally described through two manifestations. The first, LCC, accounts for research and development costs, investment costs, operating and support costs, and disposal costs over the system's entire Life Cycle. The LCC includes not only the direct costs of the acquisition program, but also includes indirect costs that would be logically attributed to the program. The second, Total Ownership Cost (TOC), consists of LCC elements as well as other infrastructure or business process costs not necessarily attributable to the program (DoD, 2008). Understanding all the costs and all the implications associated with LCCM may seem intimidating. So many unknowns and so many combinations and permutations come into play that can easily vary, making it difficult to quantify any system's total costs, especially when it matters most—during the birth of a program.

In 2006, to raise more awareness, DoD elevated the ranking of ownership costs to a Key System Attribute (KSA) in anticipation of drawing more attention early on (Kobren, 2009). Have we given LCCM enough attention to have an impact though? Probably not. And if not, how can we garner even more attention and emphasis on this KSA? Perhaps we should just call it what it is—Aggregate Management. After all, it aggregates everything that could possibly affect the cost of materializing anything that actually gets built and eventually fielded in the DoD.

Investment budgets are shrinking, and without additional attention, initial concepts designed to meet some requirement might take a lot longer to materialize or cost a whole lot more to produce and sustain—both problematic scenarios that we as a nation can ill afford. LCCM needs to be somehow re-energized. Increasing its use would trigger the robust part of the LCCM challenge—encouraging deeper thinking, acting more critically, and pursuing more creative methods to contain overall costs. Years earlier, Lt Gen James T. Stewart, USAF (Ret.), indicated one of the threats to cost containment and described it as "yo-yo funding" (Dapore & Bryant, 1984, p. 312) that persists even today in the DoD's Planning, Programming, Budgeting, and Execution (PPBE) process.

Exchange with Subject Matter Experts (SMEs)

The authors conducted two focus sessions with a handful of acquisition experts who teach the art and science of LCCM and cost estimating. Their experiences, combined with frequent contact with acquisition colleagues inside and outside the classroom, highlighted specific cost-containment issues that PMs face every day.

Their first meeting was with the Logistics SMEs. Each SME confirmed that LCCM issues persist. They noted LCCM considerations continue to be minimized up front where they could have the most significant impact. They also stressed any discussion on LCCM tends to be short-lived, especially further down the acquisition continuum and after initial modeling (R.Burroughs, personal communication, September 17, 2009).

To amplify the importance of LCCM, the SMEs recommended instituting an LCC breach construct (similar to the intent behind Nunn-McCurdy breaches). For example, if a program exceeded its LCC baseline by a fixed cost percentage similar to the construct established by Nunn-McCurdy, PMs would have to report any infringement to Congress. They also indicated it would be beneficial to establish a formulary similar to TRLs where a program could not proceed to the next phase until it demonstrated some minimum level of achievement (M. Sherman, personal communication, September 17, 2009). Currently, DoD expects LCC reassessments after an initial one is developed, but do these subsequent updates give enough attention to cost containment? Not explicitly.

The logistics SMEs emphasized both the lack in LCCM discipline and the absence of cross communication in programs that generally need it the most throughout a program's life cycle. They accentuated that funding allocations and key decisions typically seem to be focused on development and not sustainment. And, without a tool to respond to the dynamic nature of LCC that accounts for all costs, including Operations and Support (O&S), there will be little forewarning a sustainment breach might be close at hand (M. Sherman, personal communication, September 17, 2009).

A widely recognized tenet of DoD program management is that O&S costs constitute the majority of a program's total costs—a widely recognized tenet in DoD program management. As recently as March 2007, the Cost Analysis Improvement Group (CAIG) reaffirmed that "projected O&S costs average 60-65 percent of projected life-cycle costs after reviewing 34 Major Defense Acquisition Programs, or MDAPs (CAIG, 2007). Just as strikingly, at the end of a program's research and development effort and just prior to production or operations, 95 percent of the cumulative LCC has already been committed (DOE, 1997). So, is the lack of attention actually warranted in subsequent life-cycle phases given the questionable ability to influence O&S costs? The authors suspected so, but were anxious to hear and consider divergent views from the Budget, Cost, and Financial Management experts.

The authors next met with four Budget, Cost Estimating, and Financial Management (BCEFM) SMEs. This group echoed the same sentiment voiced by the Logistics SMEs: Sustainment tends to get minimized early in the development phase. However, they added that the "ilities" are generally not well-defined. They stated LCCM typically suffers from a lack of sufficient cost detail to adequately address sustainment costs that predominate once systems find their way into operations (R. Morig, personal communication, September 22, 2009).

The BCEFM SMEs quickly reached a consensus on one of the major obstacles to cost containment. They stated funding instability makes cost containment an insurmountable prospect. Already faced with many other daily programmatic challenges, they asserted that funding instability, typically manifested by perpetual budget cuts, creates a gyrating funding baseline on top of other strategic concerns including:

- Industry partners who are not necessarily motivated by cost containment
- Frequent changes in requirements
- Internal staffing shortfalls that are sometimes tough to fill
- Lack of certain key functional experience in program offices
- Cultural realities that emphasize program survival over program affordability.

The BCEFM SMEs also affirmed if PMs found a cost metric that had a strong influence in controlling costs well after the "truthful predictions," it would be widely used and could perhaps help contain costs (J. Rego, personal communication, September 22, 2009). EVM satisfies the forecasting piece of the equation, but without specific and practical motivational methods that help contain costs, its usefulness is questionable. So, do those specific methods exist today? The answer is yes. Contract incentive strategies are one of many tools available, and have been used extensively in DoD to help curb some of the escalating technical risks and associated costs. However, they have tended to provide more short-term gains than the ones needed for longer term, and more enduring outcomes in the past few years, especially when technology maturity is so fluid (GAO, 2005).

LCC IN PRACTICE TODAY

Today, in the context of containing costs in acquisition programs in the DoD, PMs are compelled to address LCCM across their program's life cycle. As mentioned earlier though, well before a PM's arrival much of the projected life-cycle costs for future systems or products is rooted in decisions made during the early phases of advanced planning and conceptual design (Blanchard, 1992). Consequently, initial LCC assessments

have always been a key component of a program's "go/no go" decision process since they address a program's affordability, and are ultimately dependent on the military department's (or agency's) ability to secure the necessary funding. Each military department and agency gives LCCM a lot of attention at the beginning of a system's life cycle. However, in addition to LCCM concerns, military departments and agencies must balance today's operational needs with future requirements, and not neglect more capable systems still in various stages of development—designed to either boost current system performance or meet new warfighter/user requirements.

LCC projections are not expected to be dormant once PMs take charge. Title 10 of the United States Code § 2434 requires the Secretary of Defense to consider an independent Life Cycle Cost Estimate (LCCE) before approving Engineering and Manufacturing Development (EMD), or Production and Deployment (P&D) of an MDAP. In practice, LCC gets looked at closely via an assortment of predictive analyses (probabilistic and deterministic) that sometimes can be difficult to absorb. So much so, that it is generally left to the experts to decipher. Very few PMs ever find themselves digging into LCC parameters. Besides, they have the experts in their respective program offices who analyze and weigh the output. Even so, many variables make it sometimes difficult for even the experts to fully quantify. The experts, who generally populate the models with key assumptions, do their best to leverage the behavior of analogous systems. Still, quantifying all the assumptions is a daunting task when so many parameters are so variable or have not been captured or qualified. Ultimately, the responsibility resides with the PM to embrace LCC estimates, but do they and their staffs revalidate these estimates on a more routine basis? Do they dive deeper into the basis of the original LCC estimate and make any necessary adjustment(s) to contain costs?

PMs recognize that LCC generally starts out with an "inferred" cost-containment element before their programs leave the initial approval process gate. What happens later is a combination of art and science mixed with some uneasiness. PMs are expected to quantify the anticipated costs of their development system across the Future Years Defense Program (FYDP). For ACAT IC and ID programs, LCC is carefully revisited by Congress in the context of Program Acquisition Unit Cost (PAUC) when costs escalate by at least 15 percent or more of the current baseline, or 30 percent or more over the original baseline (DAU, 2009a, p. 31). While operational costs can be extrapolated as a derivative, they seem to be temporarily suspended from the equation since operational costs cannot yet be easily reconciled. What happens further down the acquisition trail for most programs does not necessarily force PMs to either necessarily challenge the assumptions that were part of the original LCC equation or consider that LCC is such a dynamic process.

After Milestone B (formal initiation of an acquisition program), PMs tend to narrow their focus on managing their programs day-to-day. This

day-to-day strategy is about program survival. PMs dwell on cost, schedule, and performance parameters in the face of too little funding, too little schedule flexibility, and too many technology hurdles. If LCC models are seen as an initial forecasting apparatus only to give a reasonable grounding of all known costs—but not necessarily designed to contain costs—how could cost, schedule, and performance become more tightly integrated into the overall LCCM equation? And, what about CAIV? Where does it fit in? As originally envisioned, CAIV was designed to give PMs the flexibility to balance all the factors that could help contain costs—but has it? What do PMs have to say about CAIV? How are LCC and CAIV related? Are they related? What do PMs think about these questions? Their perspectives follow.

Survey Findings

The objective data generated by this opinion survey confirmed what some earlier studies found in LCCM. In addition, the data offered quite a few other interesting perspectives as well, especially in the way PMs view LCCM and CAIV regarding cost-containment principles. The survey also reinforced how PMs unevenly apply LCCM principles and cost-containment strategies across their programs.

Even though the opinions expressed in this survey were based on fundamental beliefs, opinions invariably drive decisions since they are inextricably linked to "experiences"—an imperative in the DoD's acquisition enterprise, and one of the key factors designed to help meet the certification requirements of the acquisition corps. In other words, opinions matter in the acquisition profession when such opinions are steeped in years of acquisition experience. Burrowing into the invaluable experiences that have shaped DoD's current PM workforce can also be a very meaningful bellwether. In this particular survey, PMs provided specific narrative comments that acknowledged certain cost-containment hurdles. The survey also found a couple of misconceptions regarding the use and usefulness of some of these cost-containment tools in the Tool Kit. The discussion that follows addresses noteworthy findings.

LCC MODEL FAMILIARITY AND EXPERIENCE

When 887 PMs were asked to rate the LCC models that they had previously used, many were simply unfamiliar with the models. Provided below are representative comments from the opinion survey results (Table 1).

> Sorry, just not that familiar with the models. Somebody else uses them and provides data to me.

As a PM, I have not been involved with the detailed execution of the specific model used to derive cost estimates. In many instances, costs and cost estimates were derived from legacy numbers of the previous program.

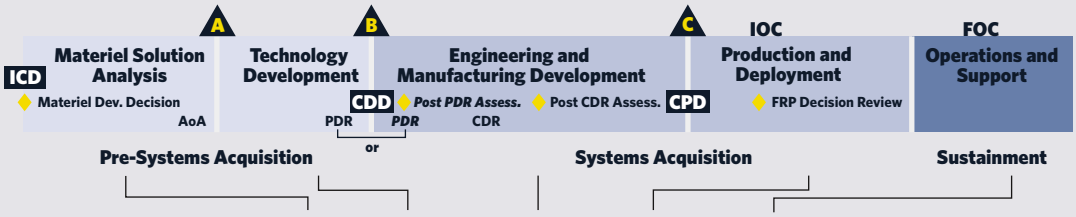
To be honest, not my field of expertise, and I am only familiar with the tools to the extent my team uses them.

I have no first-hand knowledge of any of these systems/models.

USEFULNESS OF LCC MODELS

PMs believed that the P&D and O&S phases are better predictors of costs, while the Technology Development (TD) and EMD phases are generally the most influential in driving decisions. Contrary to what the DoD would prefer, they did not believe the pre-acquisition phases (Materiel

TABLE 2. LIFE CYCLE PHASES WHERE LIFE CYCLE COST MODELS MADE AN IMPACT: VIEWS OF ACAT I PROGRAM MANAGERS



	MSA	TD	EMD	P&D	O&S	None	DK
a good cost predictor?	14	19	59	68	67	45	31
most influential in driving decisions?	45	66	91	41	34	20	28
suitable for cost containment?	15	28	52	64	48	56	33
significantly underestimated?	65	82	107	58	60	18	32

Note. MSA=Materiel Solution Analysis; TD=Technology Development; EMD=Engineering and Manufacturing Development; P&D=Production and Deployment; O&S=Operations and Support; None=No Model is a Good Predictor; DK= Don't Know Which Model is a Good Predictor.

Solution Analysis and TD) are suitable for cost containment given their inability to qualify let alone quantify some of the major "unknowns." More importantly, by the time their programs entered EMD, a large number of PMs declared that LCC models have significantly underestimated costs. PMs also stated these models need more precision in the early stages of program initiation since they drive so many future decisions (Table 2). Organizations like the CAIG recommended that PMs should seek more research that focused on "scrubbing development and procurement, more detailed analysis of sustainment profiles, and identification of causal factors" (CAIG, 2007).

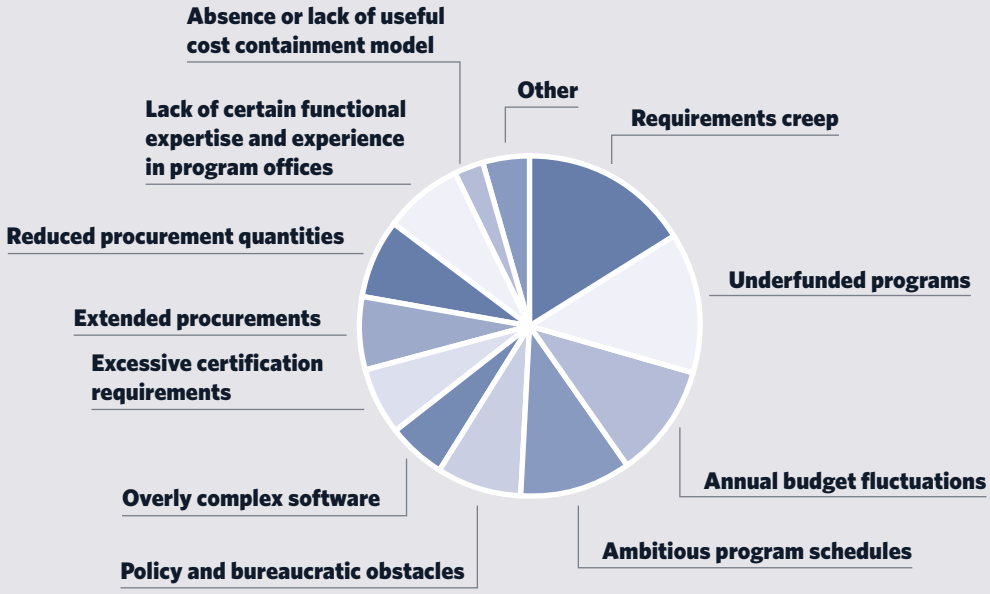
Representative Narrative Comments. A sampling of comments on the way PMs view LCCM and its cost-containment principles follows.

> Most models have many assumptions, and those assumptions are not monitored over time; and risks are not addressed to keep the assumptions valid, so the models are not valuable when decision makers really need the information.
>
> LCC for O&S appears to be generally unrealistic.
>
> As programs proceed along their life cycle, LCC doesn't seem to be appropriately updated.
>
> LCCM never captures changes allowed/forced on programs, and fails to "predict" well. Models are used early on, but eventually lose influence as "inertia" takes over and programs enter "make the best of it mode."
>
> Overly optimistic estimates.
>
> No one seems to put the thought and time into a thorough estimate of determining LCC.
>
> No one seems to update LCC and use it as a yardstick.

MAJOR OBSTACLES TO COST CONTAINMENT

Of the many typical challenges that PMs face, five obstacles accounted for a noticeable majority of the reasons that made cost containment difficult to overcome. Those five standing in the way included requirements creep, underfunded programs, annual budget fluctuations, ambitious program schedules, and too many policy and bureaucratic obstacles (Figure 7).

FIGURE 7. PROGRAMMATIC OBSTACLES THAT MAKE COST CONTAINMENT DIFFICULT TO OVERCOME: VIEWS OF ACAT I PROGRAM MANAGERS

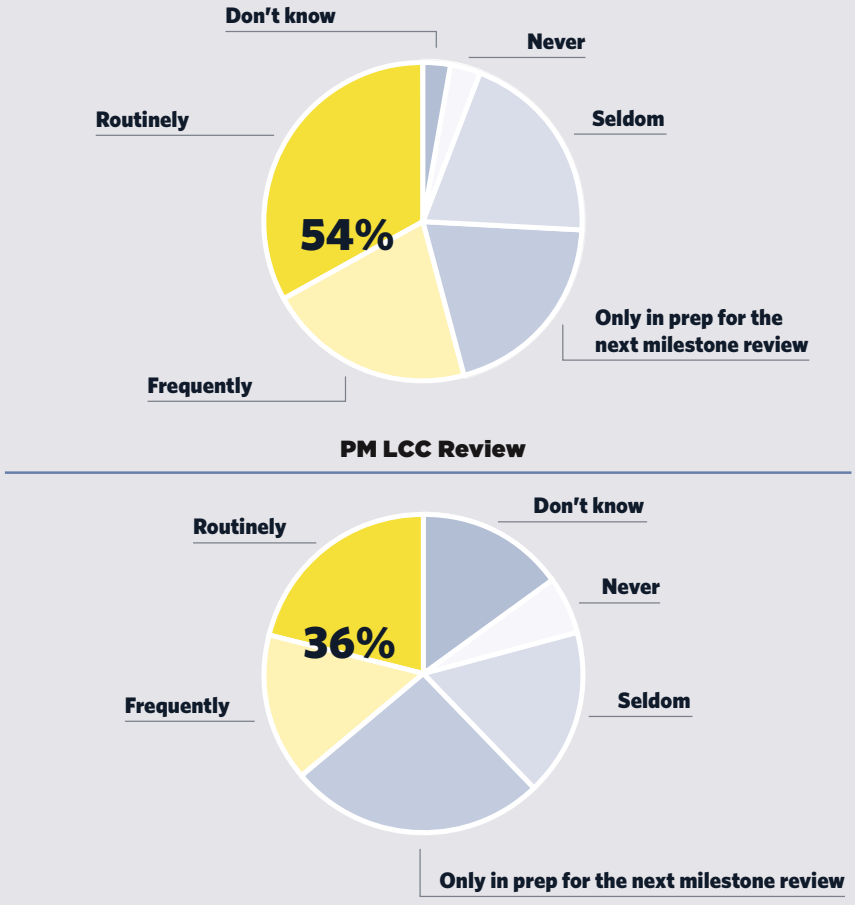


REVISIT RATES FOR LCC ESTIMATES

Despite whether revisiting LCC estimates was viewed as a burden or resource constraint, about half of the PMs routinely or frequently reviewed their program's LCCs unless in preparation for an upcoming milestone review (Figure 8). While a great forcing function, performing LCC updates only in preparation for the next milestone is probably too late to significantly influence cost containment. However, PEOs and/or senior managers showed even less interest in LCC estimates other than preparation for the next milestone (Figure 8). Without more frequent and intensive reviews by either PMs or PEOs, the ability to make cost adjustments becomes more difficult to defend.

Representative Narrative Comments. A sampling of comments on revisiting LCC highlights this seemingly low level of interest in LCC estimates other than for milestone reviews.

FIGURE 8. REVISITING LIFE CYCLE COST ESTIMATES: VIEWS OF ACAT I PROGRAM MANAGERS



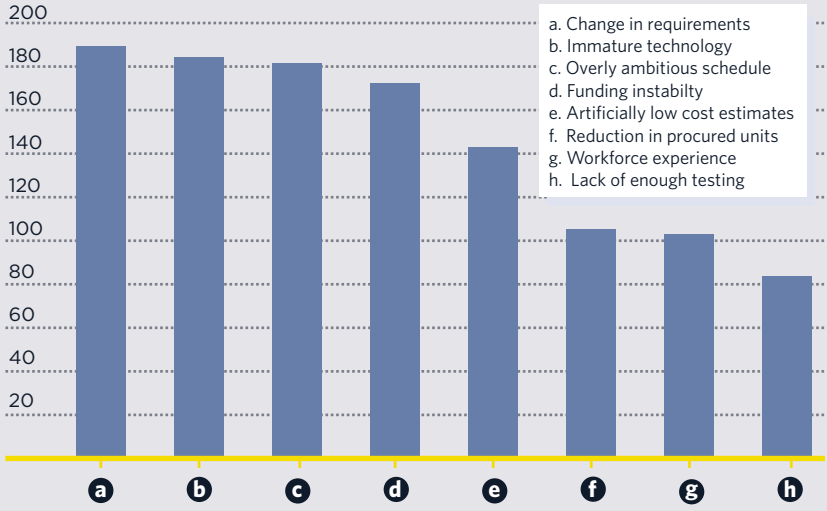
The costs that are of the most concern to me are those in the immediate execution year. I have considered out-year costs but not as much as I should have.

My focus is on providing most capability within budget, not on future life-cycle costs.

General knowledge on cost containment among all program office personnel is very low.

Many of the cost growths are based on not really understanding the requirements and instead based on assumptions on both sides.

FIGURE 9. HOW COST DRIVERS RANK IN ORDER OF SIGNIFICANCE: VIEWS OF ACAT I PROGRAM MANAGERS



SIGNIFICANT COST DRIVERS

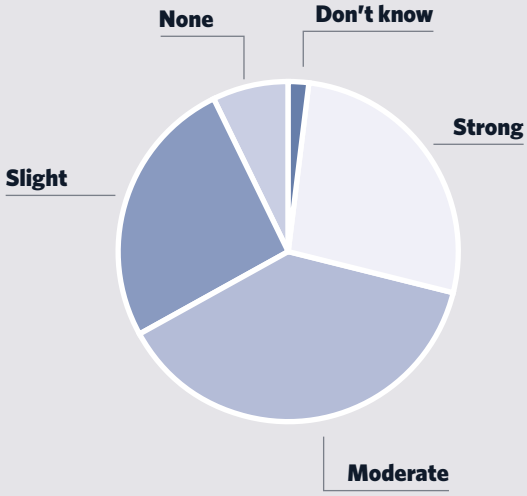
Identifying and knowing the significance of key cost drivers are paramount. Otherwise, the ability to contain costs could easily weaken. When asked how they would rate the significance of many of the classic cost drivers, PMs expressed that immature technology, funding instability, changing requirements, artificially low cost estimates, and overly ambitious schedules were the most significant (Figure 9). With the addition of artificially low cost estimates and too many policy and bureaucratic obstacles, these were the same obstacles that made cost containment difficult to overcome when an even wider selection of survey choices was posed to PMs in an earlier question (Figure 1).

CONNECTION BETWEEN CAIV AND LCC

CAIV is another key tool available to help contain costs as previously discussed. It gives PMs a flexible instrument to help quantify the undeniable relationship(s) between certain performance requirements and realistic cost constraints. However, only 65 percent of the PMs acknowledged either a "strong" or "moderate" connection to LCC (Figure 10). Subsequently, PMs might see CAIV as a quick fix only and not fully appreciate the extent of the long-term gain; not believe there is a long-term gain; or perhaps not fully believe in the concept as a whole.

Representative Narrative Comments. A sampling of comments on the relationship

FIGURE 10. STRENGTH OF CONNECTION BETWEEN CAIV AND LCC: VIEWS OF ACAT I PROGRAM MANAGERS



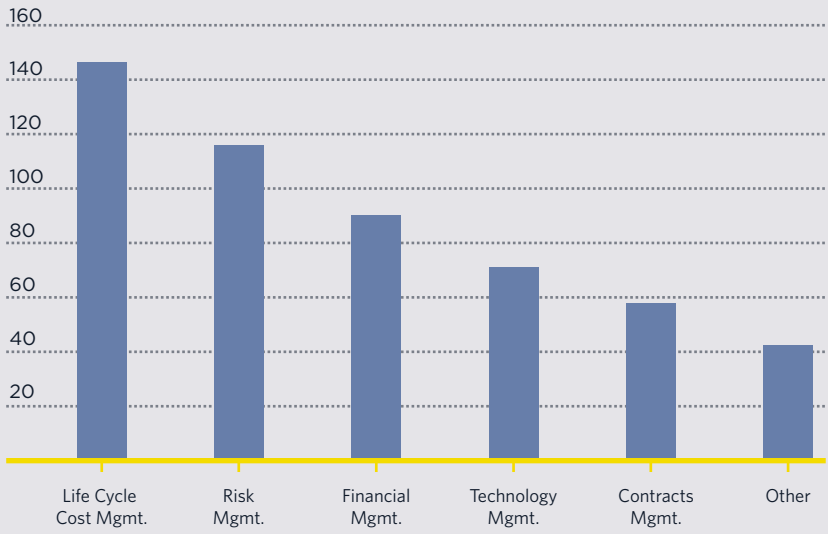
between CAIV and LCC shows a program management community less comfortable with CAIV as a cost control tool.

> Strong in theory but weak in practice.
>
> I think the relationship between LCC and CAIV has been diminished.
>
> I've never seen CAIV used to contain costs on a program.
>
> I don't believe CAIV has anything to do with CAIV. It's an artificial constraint that prevents the PM from meeting the requirements.
>
> I didn't see CAIV used in any organized way because hardly anyone on the PM team has enough practical experience.
>
> Unfortunately, the CAIV tool of last resort became common to overcome cost overruns due to funding stability and poor execution.
>
> CAIV trades are rarely supported by the requirements community. The requirements community is 99 percent focused on capability and mildly interested in long-term O&S cost-reduction efforts.

TRAINING CHALLENGES

PMs stated a need for additional training, primarily LCCM and Risk Management training, to help them better contain costs (Figure 11).

FIGURE 11. ADDITIONAL TRAINING NEEDED TO BETTER CONTAIN COSTS: VIEWS OF ACAT I PROGRAM MANAGERS



Recommendations

To reconcile some of the shortcomings of LCC and, just as importantly, better prepare PMs to contain costs and achieve more successful acquisition outcomes, the authors of this research recommend the following:

- Take the chill out of cost containment and re-energize LCCM. Make it everyone's business. Even though PMs cannot serve as LCC experts, they and their teammates should know the basis of their own LCC estimates throughout their program's life cycle, and not wait until the next milestone to make any necessary adjustment(s).
- Elevate LCC to a KPP (Key Performance Parameter)—it will compel more PMs and senior personnel to rigorously exercise LCCM principles. Establishing LCC as a KSA is not enough.
- Continuously challenge assumptions.
- Base cost decisions on programmatic realities and more current data since these influence LCC outcomes.
- Establish an LCC Continuous Learning Model (CLM) that amplifies the objectives and characteristics of an LCC model, and identifies the family of LCC models that best apply where, how, and when.

- Add an LCC best practice link to each functional Community of Practice (CoP) where PMs can learn from others.
- Establish LCCM trip wires throughout a program's life cycle, and do not penalize PMs for reporting unfavorable but essentially accurate program information to seniors or higher headquarters.
- Reward and incentivize PMs for containing and/or lowering costs.
- Develop cost-containment strategies that are carefully evaluated and painless to execute.
- Embrace innovation and dismiss mundane strategies that guarantee less-than-optimal outcomes.
- Promote more CAIV. Conceptually, CAIV was placed into the acquisition arsenal to give PMs a little more latitude with performance versus cost trade-offs. As ADM Mike Mullen, USN, Chairman of the Joint Chiefs of Staff, recently said at the Program Executive Officer/Systems Command Commanders' Conference at Fort Belvoir, Virginia, on November 4, 2009, "The acquisition community and the warfighter will have to jointly accept the 80 percent solution…we have to be realistic with what we can afford." (Mullen, 2009).
- Let PMs lead. PMs have the knowledge, skill, and ability to carefully guide their programs in the face of a complex and difficult environment.

Conclusions

This research reinforced the many contrasting perspectives that PMs possess with respect to cost containment and their ability to influence and/or control it. As originally conceived, understanding the usefulness and criticality of LCCM can have a major impact on weapons systems developments by keeping a lid on rising costs—a growing necessity. The acquisition environment will invariably change. Budgets will shrink; fewer new systems will be built and fielded; more pressure will be exerted on extending and sustaining current systems; and more pressure can be expected on containing costs—*much* more pressure. The remaining weapons systems under development will come under political fire. As external scrutiny swells, programmatic decisions will be challenged since there will be so much more information immediately available about emerging systems. So, how can PMs once and for all silence the skeptics and achieve positive acquisition outcomes? For starters, they can shock the critics by challenging the programmatic "cost status quo" at every juncture and not

just the major milestones. They can no longer "kid themselves" about what something is going to cost, as Under Secretary of Defense for Acquisition, Technology and Logistics Ashton Carter recently stated (Carter, 2009). They can increase programmatic "cost accuracy" by better understanding and re-energizing one key cost-containment practice that has seen less action or become ineffective in recent years—LCCM. Inarguably, yo-yo funding will continue. Poor outcomes need not. DoD cannot afford more of the same. Changes to DoD 5000.02 that now call for Preliminary Design Reviews (PDR) prior to Milestone B, and earlier measured prototyping to lower out-year costs will go a long way. Warfighters need every penny applied to capability, not cost overruns. Ultimately, PMs and their staffs must be more introspective and tightly integrate the art and the science of containing costs in the face of global economic changes. It's time to take the chill out of containing costs. DoD depends on it; our nation depends on it; and the warfighters need to count on it.

ACKNOWLEDGEMENTS

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Author Biographies

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APPENDIX

List of Abbreviations and Acronyms

AoA	Analysis of Alternatives
ACAT	Acquisition Category
ACWP	Actual Cost of Work Performed
ADM	Admiral
BAC	Budget at Completion
BCEFM	Business, Cost Estimating, and Financial Management
BCWP	Budget Cost for Work Performed
BCWS	Budget Cost for Work Scheduled
CAIG	Cost Analysis Improvement Group
CAIV	Cost as an Independent Variable
CARD	Cost Analysis Requirements Description
CDR	Critical Design Review
EAC	Estimate at Completion
DAU	Defense Acquisition University
CDD	Capability Development Document
CPD	Capability Production Document
DoD	Department of Defense
DOE	Department of Energy
EMD	Engineering and Manufacturing Development
EVM	Earned Value Management
FOC	Full Operational Capability
FRP	Full Rate Production
FYDP	Future Years Defense Program
GAO	Government Accountability Office
ICD	Initial Capabilities Document
IOC	Initial Operational Capability
KPP	Key Performance Parameter
KSA	Key System Attribute
LCC	Life Cycle Cost
LCCE	Life Cycle Cost Estimate
LCCM	Life Cycle Cost Management

Lt Gen	Lieutenant General
NASA	National Aeronautics & Space Administration
O&S	Operations and Support
PAUC	Program Acquisition Unit Cost
PBL	Performance-Based Logistics
PDR	Preliminary Design Review
PM	Program Manager
POE	Program Office Estimate
MDAP	Major Defense Acquisition Program
P&D	Production and Deployment
PEO	Program Executive Office
PPBE	Planning, Programming, Budgeting, and Execution
Ret.	Retired
SME	Subject Matter Expert
SYSCOM	Systems Command
TAB	Total Allocated Budget
TD	Technology Development
TOC	Total Ownership Cost
TRL	Technology Readiness Level
USAF	United States Air Force
USN	United States Navy
WBS	Work Breakdown Structure

A NEW ALPHA-OMEGA MAP FOR ACQUISITION TEST AND EVALUATION

George Axiotis

Department of Defense Acquisition Test and Evaluation (T&E) has remained the gatekeeper to Major Defense Acquisition Program production since its formalization over 25 years ago. Under T&E's oversight, the types, methods, and sources for warfighting systems have significantly evolved to meet/counter the nation's security challenges. The DoD has studied and recommended actions to accelerate Acquisition Reform for decades, while only "tweaking at the margins" for T&E. Now is the time for DoD to consider a new approach to T&E, steering away from the "buy" decision to the more relevant "acceptance" and "operational" domains. This article outlines the issues and proposes a new "Alpha-Omega" map for T&E that charts the way ahead for how DoD actually procures its weapon systems.

Keywords: *Test & Evaluation, Development Testing, Operational Testing, Acquisition Reform, Alpha-Omega Model*

image designed by Harambee Dennis and Derrick Powell »

Test and Evaluation

The new Alpha-Omega approach!

Department of Defense (DoD) leaders and numerous reform studies criticize the department's acquisition process for its inability to control spiraling costs and delays in getting systems to the user. In response, *Acquisition Reform* efforts to date focus on better requirements, efficient resources planning, as well as increasing feedback and accountability (DoD, 2004a, pp. 2–7). DoD Acquisition Test and Evaluation (T&E), comprising the formal processes, policies, personnel, equipment, facilities, and consumables necessary to develop, certify, test, and evaluate defense systems for production, has faced much of this criticism. In response, T&E reform focuses on process streamlining, reducing overhead, and further integration within the engineering process to better support the "buy" decision.

Background

The defense acquisition process, using T&E as a gatekeeper, is relatively unchanged since the Packard Commission recommendations (DoD, 1986a; DoD, 1986b, p. 11). Yet, the methods and players of DoD acquisition have fundamentally changed. Just as the Pentagon is embracing a new map for the application of military power based on an active strategy for the world as it is today, DoD needs a similar active strategy for determining who is best served by T&E (Barnett, 2004).

This article examines the fundamental influences on Acquisition T&E, the results of major studies to date on reforming Acquisition T&E, and concludes that the current emphasis on "buying" as the raison d'êtres for T&E must be replaced with a new two-tiered framework and leadership that better supports both contractual necessity and operations in the field. A new world of defense systems acquisition is emerging, driving the need for a new map for T&E based on acceptance and operation, which I suggest is the *Alpha* and *Omega* of a new T&E order.

GOOD INTENTIONS

Acquisition T&E follows a linear engineering approach to reduce risk, building insight to meet contract delivery, assessing the delivered configuration in operational environments, verifying that the system works, and certifying that the system warrants further procurement (DoD, 2008a, pt. 1, p. 12, & encl 6, pp. 51–53). Acquisition T&E is Service- and system-centric, managed through dedicated funding and contract vehicles with both *Development Testing* (DT) and *Operational Testing* (OT) supporting the "buy" decision. Public Law delays the decision beyond initial production until a submission of a report following OT:

> The Secretary of Defense shall provide that a major defense acquisition program may not proceed beyond low-rate initial

> production until initial operational test and evaluation of the program is completed. (Operational, 2009).

Yet for all its formality, T&E plays a weak role in controlling what the department actually buys. The current DoD acquisition policy allows initiation of low-rate initial production (LRIP) just after Critical Design Review. What test results are available supports this decision, but completion of testing or successful results are not formal prerequisites.

Note that DoD has no "Approval for Service Use" decision based on successful test results. The only legal hurdles to proceeding beyond LRIP are to 1) submit a report to Congress based on an OT, and 2) seek approval of the test plan in advance from the Director, Operational Test and Evaluation (DOT&E) (Operational, 2009). Again, as with LRIP, there is no requirement to pass the test, only to conduct it. Acquisition T&E today operates within a "buy" construct that neither demands minimal user-oriented testing before beginning the production process, nor formalizes the full commitment to production through successful completion of testing.

EMPHASIS ON SPEED

DoD Acquisition Reform since the mid-1990s emphasizes faster cycle times through efficient management, capitalizing on emergent technologies, fielding of early capabilities, and continuous product evolutionary cycles. The objective is to maintain competitive edge by getting to the "buy" decision faster. Yet, in World War II compelling need put emphasis on production, with T&E supporting it. Production changes, additional requirements, and performance shortfalls based on experience in the field were the foundations for block upgrades (Gropman, 1997, pp. 11, 41, 44, 100, 115). Over 60 years later, the Mine Resistant Ambush Protected vehicle procurement mimics this approach with an emphasis on T&E supporting production (GAO, 2008, pp. 8–9).

DoD works to balance procurement for both a longer term, near-peer threat, as well as near-continuous engagement against a less defined extremist threat (Chao, 2009). Senior leaders struggle with the current acquisition construct, and if given the choice would favor one that responds better to ill-defined threats, requirements that grow and change rapidly, and technologies that evolve many times within the development cycle (Testimony, 2009). Today, as in WWII, the focus is getting the right capability to the field faster, but speed-to-user is not enough to drive significant change in the current T&E process.

A NEW ENVIRONMENT—REALLY

DoD systems development and acquisition have undergone profound change in recent years, brought about by industry practice and government

policy that sets the new environment for T&E (Defense Science Board, 2008, pp. 6, 16). The following discussion provides an illustrative snapshot of the systems development and acquisition process:

REQUIREMENTS PROCESS

Requirements have steered away from the primacy of technocrats, planners, and buyers to the current end-user (DoD, 2004a, pp. 2–7). Component Commanders present unique challenges as they focus on near-term needs, have different visions for how requirements are met, and have diverse views on how advanced technology can be used. These users are less concerned with technology nuances, industrial influences, and specific capabilities. Yet, to manage successful acquisition, specificity is critical for configuration design and engineering.

SYSTEMS DEVELOPMENT

Systems are more complex, and the ability to characterize fully end-state performance before fielding is a challenge. Lead Systems Integrators (LSI) have increasingly less insight into the subsystems they are integrating and thus less confidence in understanding, and certifying to, actual systems-of-systems performance. The burden increasingly falls back to the department for resolution, accompanied by risks not just from increasingly complex systems-of-systems integration with differing maturity, but also the globalization of defense industrial capability.

INDUSTRIAL BASE

The consolidation of the Defense Industrial Base through the 1990s has left DoD with fewer options for competitive development of major capital systems. This drives systems to take on inherent design, engineering, production, and management practices, with less government insight. Key components and materials will increasingly be available only from foreign sources, inevitably leading to less control of the design and engineering (Guay, 2007, pp. 66–67). The emphasis shifts from pre-production to as-delivered product adequacy.

MISMATCHED ACQUISITION STRATEGIES

The Department of Defense Instruction (DoDI) 5000.02 relies on technologies being wrung out before initiating development, competitive prototyping used to find the "best of breed," and due diligence through T&E before production. Yet, technology evolves too quickly to tie acquisitions to fixed baselines, with initial units differing in performance and utility

from those later on in production. LSIs today deliver systems comprised of subsystems in various levels of maturity and product life cycles.

NON-SERVICE-UNIQUE SYSTEMS

In spite of the rhetoric, DoD does not buy capability—it buys "things" (systems) that are married to others, and along with end users (warfighters) form warfighting capabilities. While DoD is procuring more "joint" systems than ever before, the vast majority are still Service-centric, expected to operate in ever increasingly joint environments (DoD, 2004b, pp. 8, 12–14). It has become more difficult to characterize one system's adequacy for its own acquisition decision without interdependent systems that in and of themselves are of varying maturity levels.

NETWORKED OPERATIONS

National Defense Strategy reflects ever increasing multi-Service and Coalition operations (DoD, 2008b, p. 17). These self-forming operations preclude fully understanding interfacing systems performance or a Concept of Operations (CONOPS) to support an adequate OT in advance of a fielding decision. While the department's *Testing in a Joint Environment Roadmap* of 2004 set a vector to lash together the disparate testing capabilities within the department and industry, it can only go so far given ever-changing configuration baselines and unpredictable alterations of netted combat systems (DoD, 2008b, pp. 8, 18). Testing and subsequent evaluations will focus more on in-theater assessments.

EXPANDED ACQUISITION AUTHORITY

Once the domain of major commands, acquisition authority has spread to user- and mission-centric organizations such as Missile Defense Agency and Special Operations Command, each with its own processes. As such, systems developers will have less confidence in their system's performance as they have less insight into, or control of, interfacing systems. T&E will be less likely to depend on a priori knowledge of full system capability and default to rudimentary baseline assessments.

T&E BEYOND THE PROGRAM MANAGER

System complexity and interconnectivity mean that testers will find it difficult to build test scenarios that characterize all desired performance points within shorter development timeframes. Added to the difficulty is a less well defined threat or understanding of future CONOPS as each user

will likely tailor operations to their own needs. Acquisition will increasingly rely on tests outside the program manager's control to build just enough insight for the decision needed. Capitalizing on other data from which to build consensus is key to leveraging integrated T&E methodologies of the revised DoD 5000.02 (DoD, 2004a; DoD, 2005, p. 5; Defense Science Board, 2008).

SERVICES ARE OVERSIGHT

Service T&E has undergone massive consolidation since the mid-1990s, a situation that cannot readily be reversed in the short term. Since 2000, the Army consolidated much of its T&E organization and reduced its workforce between half and two-thirds. The Navy reduced personnel and substantially integrated its prime contractor/government testing. The Air Force further shifted DT control to prime contractors with commensurate reductions in its workforce (Defense Science Board, 2008, pp. 4–5). The burden of conducting traditional Service DT has fallen ever more frequently onto the contractors as part of the product acceptance process.

The above shows that not only how the department acquires its systems has changed, but that most cannot be addressed without fundamental change in T&E. Much of what exists in today's "new" methodologies to help nudge the acquisition process along in this new environment ignores the acquisition and T&E world as it exists today. The current processes quickly succumb under the weight of the endless reviews and forums.

NO REAL CHANGE

DoD conducted three comprehensive studies on weapons systems acquisition, with emphasis on T&E, including the Defense Acquisition Performance Assessment (DoD, 2005), the Defense Science Board Task Force on Developmental Test and Evaluation (Defense Science Board, 2008), and the Joint Defense Capabilities Study (DoD, 2004a). These authoritative studies produced a myriad of recommendations for T&E and acquisition. While each report had its emphasis, their findings and recommendations for T&E were generally similar and grouped into four broad thrusts:

1. Gain organizational efficiencies by blurring the distinction between DT and OT.
2. Push discovery earlier in the process through more rigorous testing up front.
3. Increase transparency and streamline process overhead.

4. Better utilize the planning and acquisition processes for joint warfighting needs.

All three studies presented strategies to efficiently push T&E to better support the "buy" decisions through process streamlining and combining DT and OT events, where possible, as part of an integrated T&E framework feeding a continuous thread of discovery. These form the basis of the DoD 5000 integrated T&E strategy. Yet, "integration" is fundamentally "efficiency" of questionable savings since early-on schedule and cost avoidance is lost through later rework and retest.

Unfortunately, none of the three studies reassessed T&E's role or its customer. While testing is fundamental to systems engineering and contractual compliance, Acquisition T&E is seen as a "speed bump" to procurement. In trying to serve many masters, T&E became costly, less efficient, and its reports of questionable utility to both the buyers and the users.

A FUTURE OF MANY MASTERS

Future Acquisition T&E must support two acquisition extremes—the quick-reaction, less defined threat and the long-term, near-peer threat (DoD, 2008b, pp. 8, 15–17). It must also support near-term contractual necessities as well as longer term product life-cycle processes. The emphasis is early capability delivery for initial fielding. For many complex systems, the department will only begin to understand the intricacies and capabilities of those systems once they are delivered and operating in the field. The Missile Defense Agency recognized this and developed T&E processes to support dedicated knowledge points that now form the basis for the revised DoD 5000 (Statement, 2008).

DoD must be more efficient and effective in getting information to the user and feedback from operations in the field.

As in WWII, we find ourselves with users forward deployed, persistently engaged, and needing 75 percent solutions in months. DoD must be more efficient and effective in getting information to the user and feedback from operations in the field.

A New Model

Acquisition T&E must focus on its mission, not function, to support acquisition and system complexity as they are today. T&E must uncover critical risks prior to initiating a program or, once begun, leverage the knowledge of subject matter experts as a trade-off against risk. The focus today is to provide capability as soon as it is ready, with T&E the primary mechanism for fielding the right capability at the right time. This new model proposes capability be separate but affiliated to the buying decision.

While we acquire systems through the buying process, capabilities based on aggregates of constantly evolving systems are also delivered to the user. Authority to initiate development has become the initial production approval point, reflecting the national commitment it is. The acquisition process is no longer the tidy affair it once was. Yet, it is how DoD responds that is the basis for a new T&E model, which shifts emphasis from "buying" to the more relevant product acceptance and operational domains.

AN "ALPHA-OMEGA" MODEL

The new model for T&E shifts the emphasis from buying to two basic but not necessarily sequential domains: The first domain is the world of acceptance tests, or Alpha Tests. Alpha Tests are activities to sufficiently characterize systems in support of contractual necessities, management, and initial fielding decisions. The second domain—Omega Tests—encompasses the operational assessments that follow later, which assess mission and value added over the fielding life cycle.

The vision is a T&E process that accelerates the delivery of initial DoD capability by developers, while ensuring continuous evaluation of performance in the field for current operations and future capability development. This approach supports acquisition and life-cycle activities such as the department's performance-based logistics and training.

Alpha Tests. Alpha Tests are events necessary to meet contractual requirements by capturing initial baseline capability for Service use. "Alphas" comprise all initial experiments, contractor development tests, quality tests, Service-unique interface and environmental compliance tests, and security and accreditation tests, as well as initial limited user tests. They are the necessary blending of Contractor Tests used to support delivery to the government with the traditional Service-oriented interface testing (DT) later on. Alpha Tests are a continuous aggregate of events, which are not necessarily fully completed events or *pass-fail* by their structure. Alphas are agnostic in their management and not necessarily under any one single agent's control. Their results form the basis for decision gates, and are ultimately for Service use. Alpha Tests

provide the basis for understanding delivered items at the time of delivery, not necessarily against a priori baseline parameters.

An Alpha Test construct capitalizes on all existing datasets, whether or not contractor-derived, and not throttled by concerns over the color of money, contracts, or ownership. It feeds on other Service efforts, direct and indirect program manager efforts, and training and fielding activities. Alpha fills the bin of system knowledge regardless of source. Further, an Alpha approach provides the program manager and those of affiliated efforts, the freedom to select the appropriate data from which to argue the case for delivery, up to and including the "approval for Service use" (ASU). Where a lack of data exists, the program manager is obligated to fill the void or ensure that others do their share to help build the case for ASU.

An Alpha approach also requires involvement by customers, users, and test and oversight agents for insight and advice, where practical or necessary, given their control over ASU. Less oversight is required during Alpha Test as the burden falls on the program manager to build the case necessary to deliver the incremental capability to the next user or integrator in the chain. This methodology is consistent with that used by sub-tier vendors delivering sub-systems to the LSI and consistent with the department's *Systems Engineering Guide for Systems of Systems* (DoD, 2008c, pp. 21, 24–25).

Omega Tests. Omega Tests are those scripted and unscripted, supervised and un-supervised, demonstrations of systems operation in the field. Users, OT agents, and oversight, training, logistics, and doctrine agents focus on system utility and are less concerned with the buying decision. Omega Tests capitalize on data and experience in the field, not to pass-fail (since the department has long since committed to the program), but to build on the baseline understanding of capabilities and limitations at ASU. Omega feedback also forms the basis for the next capability increment, or decision to move on to new capabilities. Data and insight, through formal reports, assessments, or observations, are provided to the community at large, including operations research, requirements generators, product life-cycle managers, program/project managers, oversight entities such as Service Chiefs and DOT&E, and training and doctrine agents.

A significant issue, using today's operational test and evaluation construct, is pegging deficiencies uncovered in complex systems-of-systems tests for a product-centered acquisition process. An Omega strategy broadens the responsibility as Omega Tests are funded through a myriad of single and combined sources, including component commanders; training and doctrine commands; research, logistics, and engineering activities; intelligence agencies; programs; and other Service acquisition agents.

This approach expands the community of Omega agents far beyond that limited by the Service Operational Test Agencies (OTA) and removes the "black hat" image of today's operational testers. There would be less concern that OTA input blurs the role between system buying and fielding. Nevertheless, U.S.C. Title 10 must be revisited given the requirement to conduct an OT; and for DOT&E, an independent operational assessment must be conducted prior to proceeding beyond LRIP. In all likelihood, DoD will need consensus with Congress to either formalize a supervised period of Alpha testing on basic systems to support independent reporting, or use the first Omega evaluation as the gatekeeper to further cross-Service capabilities. The latter would seem more appropriate as Congress and the DoD get a better picture of capabilities fielded and future needs, with effectiveness judged through a broader evaluation lens.

ORGANIZING TO THE ALPHA AND OMEGA

Service field activities would continue to function as life-cycle agents and as centrally or direct-funded Alpha testers, supporting any Alpha event whether Service-specific or at contractor sites. Alpha, being nonpartisan, can be managed either before formal program initiation, during program phases, or as part of post-production life-cycle support. Much of this structure is already in place, as test personnel at DoD Major Range and Test Facility Base activities are direct customer-funded operations.

Service OTAs, freed from the grip of the acquisition process, support customers of all types. OTA and Omega would be funded through a much broader array of customers less tied to programs. The expeditionary OTA, or other agents tapped for such roles, deploy to theaters of operations or specific test sites to act as user test or evaluation agents. A much smaller senior cadre would be reserved for overseeing Alpha events supporting ASU decisions through working arrangements with program offices. Their portfolio of products and services would be greater than current program-centric assessments. The OTAs would be managed by the Services, overseen by DOT&E, and free to expand their operations worldwide, including foreign systems. This new and expanded role sets the OTA on a path to supporting a wider array of warfighting capabilities.

The emphasis is on empowering with responsibility based on a closer working relationship between the developers and users. The Alpha-Omega strategy relies on three simple rules by which to frame progress and argue for ASU, when appropriate:

1. What warfighting capability is provided (not the "thing" being procured)?
2. To what degree does it work, and how do you know (capabilities/limitations as delivered)?

3. What are the impacts to other systems (risk assessment across the doctrine, organization, training, materiel, leadership and education, personnel, and facilities)?

EMPOWERED TESTERS

Testers and evaluators increase their impact on new program vectors. The emphasis is not on whether systems are good enough to buy (as they are already being bought), but rather what new vector must be set, based on performance and deficiencies observed. OTAs plan, manage, and oversee Omega Tests as well as assess capability in the field, working with the users to vet future capabilities, upgrades, or changes to doctrine and CONOPS. A new Joint Omega Executive provides both independent and collaborative insight of systems-of-systems operations in the field to support capability increments.

THE RIGHT OVERSIGHT

The Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, through either the Director for Systems and Software Engineering, or the new Director for Developmental T&E (Weapons, 2009) oversee Alpha activities, ensuring that adequate insight and progress support (along with user representatives) are provided once capabilities are fielded. This lead would also ensure sufficient capacity, training, and capability exist at T&E facilities. The DOT&E would oversee all Omega testing, advise on operational realism for Alpha events, and continue to report independently to Congress. Oversight agents will focus less on technical detail, but rather on validating that achieved capability is usable and understood by the users.

A NEW TEMP

The department has built an entire cottage industry around the Test and Evaluation Master Plan (TEMP), whose value is to document the T&E commitment between program manager and the OTA. Yet, in the pace of today's programmatic change, the TEMP becomes rapidly outdated. Under this process, the TEMP would not focus on a program's 10-year T&E plan, but rather outline the top-level strategy of a shorter period leading to the next ASU decision, focusing on system maturity, external resources, and likely data collection points.

Conclusions

The recently revised DoD 5000 strengthens the primacy of fielding, through acquisition, with T&E primarily supporting the latter. This article proposed a new map for Acquisition T&E, supporting today's persistent engagement as well as the next near-peer threat. The DoD cannot wait for optimal solutions before fielding capabilities or rely solely on T&E as its gatekeeper. This new Alpha-Omega strategy, based on acceptance testing for delivery and operational use evaluations in the field, is on par with acquisition as it exists today, not on how we wish it to be. This strategy recognizes and accepts T&E's core role in engineering and contract compliance, as well as T&E's ultimate customer—the warfighter.

This article examined how the acquisition environment has changed and how the process itself has evolved as it continues to adapt to this new reality. Nevertheless, recent authoritative studies on T&E have not recognized these fundamental changes in the landscape and have only recommended modest changes to T&E processes to speed them up a bit and make them cost a little less. T&E must emerge from its relegated place in the shadows of acquisition to support a new customer set. The Alpha-Omega strategy offers the hope of changing this by shifting the traditional OTA role out of the "buy" process into the more relevant fielding process as the agent of choice for a much wider set of customers, including not only Service acquisition and life-cycle agents, but also component commanders, trainers and doctrine agents, and requirements developers.

The Alpha-Omega Strategy for T&E supports bringing capability to the field faster, with better understanding of capabilities and limitations, across a broader set of systems-of-systems than current methodologies—streamlined or not—can ever do. The time is right for fundamental change.

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THE F119 ENGINE: A SUCCESS STORY OF HUMAN SYSTEMS INTEGRATION IN ACQUISITION

2ndLt Kevin K. Liu, USMC, Ricardo Valerdi, Donna H. Rhodes, Col Larry Kimm, USAF, and Lt Col Alvis Headen, USAF

The Department of Defense recently mandated the incorporation of Human Systems Integration (HSI) early in the acquisition cycle to improve system performance and reduce ownership cost. However, little documentation of successful examples of HSI within the context of systems engineering exists, making it difficult for the acquisition community to disseminate and apply best practices. This article presents a case study of a large Air Force project that represents a successful application of HSI. The authors explore the influence of both the Air Force and the project contractor. Additionally, they identify top-level leadership support for integrating HSI into systems engineering processes as key to HSI success, reinforcing the importance of treating HSI as an integral part of pre-Milestone A activities.

Keywords: *Human Systems Integration, Systems Engineering, Acquisition Process, Human Factors Engineering, Integrated Product Development*

image designed by Harambee Dennis »

HSI

Manpower

Personnel

Training

Environment

Safety

Occupational Health

Habitability

Survivability

Human Factors Engineering

optimize total system performance

Human Systems Integration (HSI) is defined as the "interdisciplinary technical and management processes for integrating human considerations within and across all system elements; an essential enabler to *systems engineering* practice" (Haskins, 2007). The primary objective of HSI is to integrate the human as a critical system element, regardless of whether humans in the system function as individuals, teams, or organizations. The discipline seeks to treat humans as equally important to system design as are other system elements, such as hardware and software.

Many stakeholders have attempted to define HSI, and the number and definitions of HSI domains vary by organization (Department of Defense [DoD], 2008). However, DoD guidance makes it clear that the ultimate goal of any HSI program should be to "optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system" (DoD, 2008; Department of the Army, 2005; Department of the Navy, 2008). Since this article documents a case study of HSI practice within the Air Force, we provide the nine domains of HSI, as highlighted on the previous page.

Large defense projects require significant systems engineering effort that can quickly drive up costs. At the same time, defense projects typically have high requirements for survivability, safety, and other human considerations. As mentioned earlier, DoD is interested in HSI as a means of both reducing cost (Wallace et al., 2007), shortening acquisition cycles (Mack et al., 2007), and improving system performance (DoD, 2008). Published case studies and best practices have highlighted the technical and economic benefits of successful HSI practice (Booher, 1997; Landsburg et al., 2008). These studies and others have consistently emphasized the importance of taking HSI into consideration early in the *acquisition process*.

Although HSI evolved from the study of Human Factors, it expands upon the latter discipline by incorporating a broader range of human considerations such as occupational health, training, and survivability over the system life cycle. Depending on the particular definitions being used, the areas covered by Human Factors and HSI can overlap. The best way to understand the differences between the two terms is that HSI is at heart a subset of systems engineering. HSI work must take place in conjunction with systems engineering and applies to all the same acquisition phases. Historically, many engineers have tended to view human factors (and therefore HSI) as a means of identifying problems with a design, rather than as an enabler of good design (Harrison & Forster, 2003). Although HSI analyses in the later phases of acquisition are an important part of HSI success, the case study presented in this article focuses on the role and impacts of HSI in systems engineering throughout the acquisition life cycle.

Method

This case study documents HSI activities during the development of Pratt & Whitney's F119 engine, which powers the $143 million Lockheed Martin F-22 Raptor fighter aircraft (Drew, 2008). The F-22 Raptor (Figure 1) fulfils the air superiority role in the Air Force by using a package of technologies to allow pilots to "track, identify, shoot, and kill air-to-air threats before being detected" (Department of the Air Force, 2008b). Although the Air Force HSI Office was not formalized until 2007, much of the work done on the F-22 and F119 in the 1980s and 1990s spans the domains of HSI, making the F119 a best practice of HSI in the Air Force.

In designing the study, we followed Yin's (2003) approach for identifying five important components to case study design: 1) a study's questions, 2) its proposition, 3) its units of analysis, 4) the logic linking the data to the propositions, and 5) the criteria for interpreting the findings.

FIGURE 1. THE F-22 RAPTOR

Flying High. The Lockheed Martin/Boeing F-22 Raptor is a fifth-generation fighter aircraft that uses stealth technology. It was designed primarily as an air superiority fighter, but has additional capabilities that include ground attack, electronic warfare, and signals intelligence roles. The Raptor was first introduced into the U.S. Air Force in December 2005. Retrieved 2009 from *Inside AF.mil* [Web page] at http://www.af.mil/shared/media/photodb/photos/090123-F-2828D-942.JPG. *U.S. Air Force photo by Air Force Master Sgt. A. Dunaway (2008)*

The case study was designed around three central research questions:

1. How did Pratt & Whitney determine how much HSI effort would be needed?
2. How much did HSI effort eventually cost?
3. How did HSI fit into the larger systems engineering picture?

The first two of our research questions reflect our ongoing research on the economics of HSI. Discussion of this case study from the perspective of cost estimation can be found in Liu, Valerdi, and Rhodes (2009), and Valerdi and Liu (2009). In this article, we address the third research question.

Since we sought to describe *how* the F119 became a best practice of HSI, we designed our study as a single-case descriptive study. Our proposition was that HSI effort could be isolated from the larger systems engineering effort spent. Initially, we hoped to establish a quantitative relationship between HSI cost and systems engineering cost, but were also interested in identifying the critical factors that led to successful HSI implementation. Although our third research question was originally meant to better our understanding of HSI cost, we found in the course of our case study that the role of HSI in systems engineering is not well understood and would benefit from the documentation of a best practice.

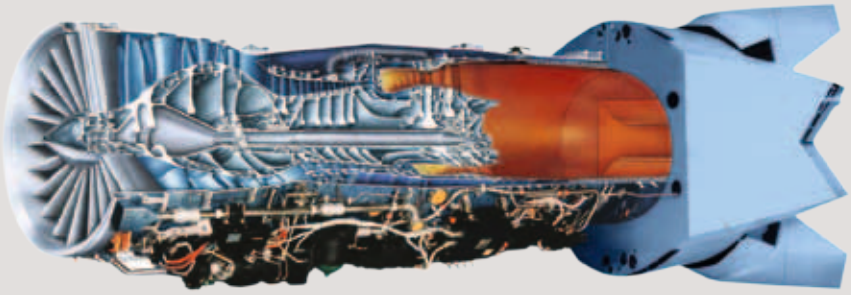
We sought to analyze the early development of the F119, from concept development until major engineering and manufacturing development (EMD). Our unit of analysis was the engineering organization responsible for HSI on the F119 at Pratt & Whitney. Since historical data on specific costs associated with HSI activities were not available either because data were not kept or the records could not be found, we depended on Pratt & Whitney employees familiar with the F119 to build an understanding of its development. We conducted a series of interviews with Pratt & Whitney engineers who were active in the development of the F119, in both technical and management roles. Based on our central proposition and research questions, our interviews focused both on life-cycle cost measurement as well as on systems engineering and HSI methodology. With this information, we were able to identify key HSI success factors. We concluded the case study by validating our results using existing literature on the F119 and the F-22 and by comparing the results of our interviews with multiple engineers.

EARLY AIR FORCE EMPHASIS ON RELIABILITY AND MAINTAINABILITY

The Defense Resources Board approved the creation of the Advanced Tactical Fighter (ATF) program in November of 1981 to create a military jet that would be able to guarantee air superiority against the Soviet Union. This fighter was meant to replace the F-15 Eagle, which had previously filled this role. A team composed of Lockheed, Boeing, and General Dynamics competed against Northrop Grumman to develop the fighter. In 1991, the

ATF contract was awarded to the Lockheed team's F-22, powered by Pratt & Whitney's F119 engine (Figure 2). Then-Secretary of the Air Force Donald Rice noted that an important consideration in the awarding of the contract was the fact that the F-22's engines offered superior reliability and maintainability (Bolkcom, 2007).

FIGURE 2. F119 ENGINE



Cutaway of Pratt & Whitney's (P&W) F119-PW-100 engine. Two F119-PW-100 engines power the Lockheed Martin F-22 Raptor, the U.S. Air Force's new stealth fighter. The F119 features a unique thrust vectoring nozzle, integrated stealth characteristics, and the capability to supercruise, or achieve Mach 1.5 without afterburner. Adapted from "Pratt & Whitney's F119 Engine Receives ISR Approval from USAF, Surpasses 4,000 Flight Hours, Demonstrates Unprecedented Reliability," Pratt & Whitney Press Release, September 16, 2002. Retrieved 2009 from http://www.pw.utc.com/Media+Center/Press+Releases/Pratt+&+Whitney's+F119+Engine+Receives+ISR+Approval+from+USAF,+Surpasses+4,000+Flight+Hours,+Demonstrates+Unprecedented+Reliability.

The Air Force placed an emphasis on reliability and maintainability from the beginning of the ATF program as well as throughout the Joint Advanced Fighter Engine program (JAFE)—the program to develop the engine for the ATF. In June of 1983, four general officers representing the Army, Navy, and Air Force signed a joint agreement in order to "emphasize to the DoD and defense contractor communities the critical importance of improving operational system availability by making weapon system readiness and support enhancement high-priority areas for all our research and development activities" (Keith et al., 1983). Later that year, the director of the JAFE program sent a memorandum to participants in the program, including Pratt & Whitney, asking them to consider that over 50 percent of the Air Force budget was then devoted to logistics, and that the problem would only worsen (Reynolds, 1983).

To address this increase in logistics cost and determine ways to develop creative solutions, the Air Force created the Reliability, Maintainability, & Sustainability (RM&S) program in 1984 (Gillette, 1994). Besides reducing life-cycle cost, the RM&S program also sought to address the reliability and durability problems that had plagued Pratt & Whitney's previous F100 engine, which powered the Air Force's F-15 Eagle. Developed in the 1970s, the F-15 was developed specifically to counter the Russian MiG-25. Therefore, emphasis was placed on performance during the development of both the F-15 and F100. Unfortunately, the high performance of the F100 meant that the engine was more prone to failure and downtime. By the 1980s, the Russian air superiority threat was no longer as pressing as when the F-15 was developed, and supportability was emphasized over performance. As a result, the Air Force wanted improved RM&S not only on the F119 engine, but on development of the F-22 as a whole. Specific supportability goals for the F-22 were announced as early as 1983 (Aronstein et al., 1998).

UNDERSTANDING CUSTOMER NEEDS

The F-22 engine competition was not the only instance in which Pratt & Whitney had competed with General Electric. Both companies had developed engines to power the Air Force's F-16 Fighting Falcon. In the end, General Electric provided the majority of engines for that platform. Pratt & Whitney saw success in the JAFE program as critical to the company's ability to continue to compete in the military engine market. For the F119 engine, Pratt & Whitney decided not only to meet the Air Force's RM&S requirements, but to emphasize designing for the maintainer throughout all aspects of the program. The company's approach exemplified the best practices of what is now known as HSI.

Pratt & Whitney conducted approximately 200 trade studies as contracted deliverables for the Air Force. Pratt & Whitney engineers also estimated they had conducted thousands of informal trade studies for internal use. These trade studies used evaluation criteria, including safety; supportability; reliability, maintainability, operability, and stability; and manpower, personnel, and training (Deskin & Yankel, 2002).

Figures of merit were developed for the trade studies to define a consistent set of criteria upon which to assess the trade studies. Pratt & Whitney engineers used these figures of merit to determine which engineering groups would participate in each trade study.

As is often the case in the development of complex defense systems, responsibilities for the various domains of HSI are distributed among many different organizations at Pratt & Whitney. Of the nine domains of HSI (see Table), seven were represented in Pratt & Whitney's engineering groups. Maintainability, Survivability, Safety, Training, and Materials were all engineering groups at Pratt & Whitney. Manpower, Personnel, and *Human*

TABLE. NINE DOMAINS OF HUMAN SYSTEMS INTEGRATION

Manpower	The number and mix of personnel (military, civilian, and contractor) authorized and available to train, operate, maintain, and support each system.
Personnel	The human aptitudes, skills, knowledge, experience levels, and abilities required to operate, maintain, and support a system at the time it is fielded.
Training	The instruction and resources required to provide personnel with requisite knowledge, skills, and abilities to properly operate, maintain, and support a system.
Environment	In the context of HSI, the conditions in and around the system and the concepts of operation that affect the human's ability to function as a part of the system, as well as the requirements necessary to protect the system from the environment (e.g., radiation, temperature, acceleration forces, all-weather ops, day-night ops, laser exposure, air quality within and around the system, etc.).
Safety	The application of systems engineering and systems management in conducting hazard, safety, and risk analysis in system design and development to ensure that all systems, subsystems, and their interfaces operate effectively, without sustaining failures or jeopardizing the safety and health of operators, maintainers, and the system mission.
Occupational Health	The consideration of design features that minimize risk of injury, acute and/or chronic illness or disability, and/or that reduce job performance of personnel who operate, maintain, or support the system.
Habitability	Factors of living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population that contribute directly to personnel effectiveness and mission accomplishment, and often preclude recruitment and retention problems.
Survivability	The ability of a system, including its operators, maintainers, and sustainers, to withstand the risk of damage, injury, loss of mission capability, or destruction.
Human Factors Engineering	The comprehensive integration of human capabilities and limitations (cognitive, physical, sensory, and team dynamics) into systems design to optimize human interfaces and facilitate human performance in training, operation, maintenance, support, and sustainment of a system.

Factors Engineering were taken into account by the Maintainability group. Human Factors Engineering also impacted the Safety group. Occupational Health was considered by both the Safety group and Materials group, which dealt with hazardous materials as one of its responsibilities. While there was an Environmental Health and Safety (EH&S) group at Pratt & Whitney, it dealt with EH&S within the organization itself and did not impact engine design. Habitability was not an important consideration in the engine design.

TOP-LEVEL LEADERSHIP AND INTEGRATED PRODUCT DEVELOPMENT

The major requirements for RM&S came directly from the Air Force. The JAFE program in particular was intended to improve RM&S by "reducing the parts count, eliminating maintenance nuisances such as safety wire, reducing special-use tools, using common fasteners, improving durability, improving diagnostics, etc." (Aronstein et al., 1998). While General Electric made significant RM&S improvements to its F120 engine during this time period, Pratt & Whitney centered its competitive strategy on RM&S superiority.

During the Joint Advanced Fighter Engine competition, Pratt & Whitney participated in the Air Force's "Blue Two" program. The name refers to the involvement of maintenance workers in the Air Force—"blue-suiters." The program brought Pratt & Whitney engineers to Air Force maintenance facilities so that the engine designers could experience first-hand the challenges created for maintainers by their designs. Maintainers showed how tools were poorly designed, manuals had unclear instructions, and jobs supposedly meant for one person took two or more to complete safely.

Many of the features for which the F119 would come to be praised were a result of leadership commitment to HSI. Frank Gillette, the Chief Engineer of the F119, served in various leadership positions on the F119 project, eventually leading a team of over 900 engineers. In interviews with Pratt & Whitney employees familiar with the F119, Gillette was identified as a driving force behind ensuring buy-in to HSI principles.

When the Pratt & Whitney team returned from its Blue Two experience to work on the F119, Gillette captured the lessons learned from the site visits in a series of presentations. These presentations were then shown to every engineer on the F119 team. Gillette also established design ground rules based on the requirements of the maintainer.

One of the most important requirements for the F119 was that only five hand tools should be used to service the entire engine. All Line Replaceable Units (LRUs) would have to be "one-deep," meaning that the engine would have to be serviceable without removal of any other LRUs, and each LRU would have to be removable using a single tool within a 20-minute window (Gillette, 1994). Maintenance would have to be possible while wearing hazardous environment protection clothing. Maintenance tasks would

have to accommodate the heights of maintainers from the 5th percentile female to the 95th percentile male+ (Gillette, 1994; Aronstein et al., 1998). In addition:

> Built-in test and diagnostics were integrated with the aircraft support system, eliminating the need for a special engine support system. Lockwire was eliminated, and torque wrenches were no longer required for "B" nut installations. The engine was designed with built-in threadless borescope ports, axially split cases, oil sight gauges, and integrated diagnostics. Other improvements were a modular design…color-coded harnesses, interchangeable components, quick disconnects, automated integrated maintenance system, no component rigging, no trim required, computer-based training, electronic technical orders, and foreign object damage and corrosion-resistant. These advances were intended to reduce operational-level and intermediate-level maintenance items by 75 percent and depot-level tools by 60 percent, with a 40 percent reduction in average tool weight. (Aronstein et al., 1998)

These innovations were only possible using the *Integrated Product Development* (IPD) concept. Whereas on previous projects, engineering groups at Pratt & Whitney each worked in their own respective disciplines, under IPD teams of engineers from varying disciplines were able to provide design engineers with the perspectives they needed to see the full impacts of their design decisions.

CONTINUING ACCOUNTABILITY AND ENFORCEMENT OF HSI

Adoption of the IPD concept brought various stakeholders together early in the design process and ensured multidisciplinary input through design and development. As a matter of policy, whenever a design change needed to be made, the originating group would submit the change to be reviewed by a Configuration Control Board (CCB). CCBs were composed of senior engineers from multiple engineering groups. At CCB meetings, each group with a stake in a particular design change would explain the impacts of that change to the chair of the CCB, typically a design engineer. The chair would then weigh the different considerations of the design change and either approve/disapprove the change or recommend further analysis be done.

In instances when Air Force requirements needed to be changed, the originating group would submit a Component Integration Change Request (CICR), which would then be internally debated much as with design changes. CICRs were typically initiated when it was determined that a particular requirement might not be in the best interests of the customer or when one requirement conflicted with another. Once a CICR was finalized

internally by all of Pratt & Whitney's engineering groups, it was presented to the Air Force, which would then make the final decision on whether a requirement could be eliminated, modified, or waived.

The processes for design and requirement change ensured that the work of one group did not create unforeseen problems for another. However, change requests were typically made in response to problems that arose during development. Although reacting to and fixing these problems were important, it took proactive leadership to make sure HSI principles were being followed even when no problems were apparent.

Frank Gillette created several policies that ensured engineers kept RM&S considerations constantly in mind. All part design drawings were required to be annotated with the tools needed to service that part. This helped to achieve the goal of being able to service the entire engine with only five hand tools (in the end, the F119 required five two-sided hand tools and one other tool, sometimes described as 11 tools total).

Gillette also insisted on the development of several full-scale mock-ups of the F119. These mock-ups came at a considerable cost (over $2 million each, while the cost of an engine was then about $7 million) but allowed engineers to see whether their designs had really achieved maintainability goals. Engineers were asked to service LRUs on the mock-ups by hand to ensure that they were each indeed only "one-deep." When an LRU was shown to not meet that requirement, the teams responsible for those LRUs were asked to redesign them.

HSI EFFORTS LEAD TO COMPETITION SUCCESS

Leading up to the major EMD contracts awarded in 1991, Pratt & Whitney conducted 400 distinct demonstrations of the F119's RM&S features. The F119 also accrued over 110,000 hours of component tests and 3,000 hours of full-up engine tests, representing a thirtyfold increase in total test hours over its predecessor, the F100 (Aronstein et al., 1998). Pratt & Whitney was willing to spend significant effort on demonstrating the F119's RM&S features because the company had recently been beat out by General Electric in their competition to provide engines for the Air Force's F-16 Fighting Falcon, and therefore saw the Joint Advanced Fighter Engine competition as its last chance to stay in the military engine market.

In 1991, both Pratt & Whitney and General Electric were awarded contracts worth $290 million to complete the EMD phase of competition. The companies were given independence as to the number and types of tests that would be run on their engines, while the Air Force provided safety oversight. As a result, Pratt & Whitney chose to log about 50 percent more test hours than General Electric (Aronstein et al., 1998).

General Electric chose to emphasize the performance of its F120 engine over RM&S, though the F120 did meet the Air Force's RM&S requirements. The F120 was the world's first flyable variable cycle engine (Hasselrot &

Montgomerie, 2005). This meant that the F120 was able to change from turbofan to turbojet configuration to achieve maximum performance in multiple flight situations. The F120 was tested in both Lockheed's YF-22 and Northrop Grumman's YF-23 prototypes, demonstrating better maximum speed and supercruise than Pratt & Whitney's F119 in both cases (Aronstein et al., 1998). The dry weight of the F119 is classified, making it impossible to calculate its exact thrust-to-weight ratio. However, Pratt & Whitney advertises the F119 as a 35,000-lb thrust class engine, putting it into the same thrust class as the F120 (Gunston, 2007).

Despite the F120's superior performance in the air and higher thrust-to-weight ratio, on April 23, 1991, the Air Force chose the combination of Pratt & Whitney's F119 and Lockheed's YF-22 to be developed into the F-22. Pratt & Whitney had repeatedly demonstrated a better understanding of the Air Force's RM&S needs, investing more time and money into demonstrations and internal efforts than its competitor. It also avoided the increased risk of developing a variable cycle engine, at the time considered a relatively new and untested technology. By 1991, the Air Force's RM&S program was less focused on reducing downtime and more concerned with reducing life-cycle costs. Pratt & Whitney had presented a management plan and development schedule that the Air Force considered sensitive to their needs (Aronstein et al., 1998). On August 2, 1991, contracts worth $11 billion were awarded to Lockheed and Pratt & Whitney (Bolkcom, 2007), demonstrating the Air Force's commitment to HSI. Pratt & Whitney's portion was worth $1.375 billion alone (Aronstein et al., 1998).

KEY HSI SUCCESS FACTORS

The Air Force's early and continuing emphasis on RM&S was captured via requirements. Although dating back to 2003 the General Accounting Office (GAO, now the Government Accountability Office) was still advocating for more equal consideration of reliability and maintainability in requirements definition (GAO, 2003), our case study showed that the Air Force had already understood this principle a decade prior. The Air Force's initial guidance to emphasize RM&S shaped the design approach of all of its contractors.

The actions of both the Air Force and Pratt & Whitney were examples of combining top-level leadership's role within systems engineering practices. The Air Force set formal requirements and expected deliverable trade studies, but it also set early supportability goals, released memoranda explaining their intent, and funded programs to show Pratt & Whitney engineers actual maintenance conditions. In its own right, Pratt & Whitney embraced the IPD approach along with IPD's subordinate systems engineering processes, but also invested significant effort to develop mock-ups, conduct additional testing, and hold engineers accountable for RM&S standards.

As a result, we identify three factors as key to the success of HSI in the context of systems engineering in the F119 program:

1. Air Force policy to elevate the visibility of HSI
2. Pratt & Whitney's willingness to internalize HSI practices and enforce accountability for HSI
3. The integration of HSI and systems engineering in the early phases of the acquisition life cycle.

Conclusions

In this case study, we document an example of successful HSI. HSI strongly influenced the development of Pratt & Whitney's F119 turbofan engine from early in the acquisition life cycle through EMD.

Many traditional systems engineering activities also were clearly impacted. Conversations with Pratt & Whitney engineers indicated that by the time HSI requirements were integrated into the engine, the cost of specific HSI activities could no longer be distinguished from other systems engineering costs. In addition, Pratt & Whitney never had a formal organization responsible for all HSI considerations. Instead, responsibilities for HSI were spread between multiple engineering groups. The lack of a formal HSI group did not prevent the F119 from becoming a best practice of HSI. To the contrary, the fact that HSI considerations were tightly coupled to other systems engineering practices was one the project's major strengths.

This case study represents a first step toward establishing the role of HSI in the context of systems engineering. As more success stories are documented, the ability to disseminate best practices throughout the defense acquisition community will improve and will lead to reduced lifecycle costs and improved performance.

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The work presented in this article is part of a larger ongoing project to understand the economics of Human Systems Integration, focusing on cost estimation approaches and leading indicators. The authors have also produced a series of conference papers and a book chapter on this topic, which are cited in the reference section.

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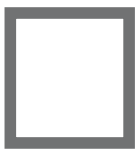

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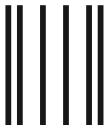

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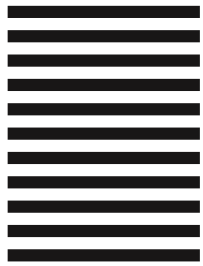

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