Report of the
Defense Science Board
2010 Summer Study on

Enhancing Adaptability of U.S. Military Forces

Part A. Main Report

January 2011

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB).

The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense. The Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces completed its information-gathering in August 2010.

This report is unclassified and cleared for public release.

OFFICE OF THE SECRETARY OF DEFENSE
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WASHINGTON, DC 20301–3140

DEFENSE SCIENCE BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS

SUBJECT: Final Report of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces

I am pleased to forward the final report of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces. This report offers important recommendations for how the Department of Defense can better face the rapidly changing security environment of the 21st century by increasing its adaptability.

The study used business and government case studies to derive its definition of adaptability which identified the key elements as the ability and willingness to anticipate the need for change, to prepare for that change, and to implement changes in a timely and effective manner in response to the surrounding environment. The study identified a strategy to promote the elements of adaptability in DOD, with an ultimate goal of improving mission effectiveness. The key elements of this strategy are:

- align enterprise functions to support mission outcomes
- reduce uncertainty through better global awareness
- prepare for degraded operations
- enhance the adaptability of the workforce
- change the culture

In the judgment of the Defense Science Board, the Department can achieve greater adaptability across the enterprise—moving beyond the cultural, organizational, and regulatory barriers that exist.

I endorse all of the study's recommendations and encourage you to forward the report to the Secretary of Defense.

Paul S Kaminski

Dr. Paul Kaminski
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
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DEFENSE SCIENCE BOARD

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces

Today's military forces face an increased level of operational uncertainty and must be ready to adapt rapidly. Adversaries evolve in days, weeks, or months, and U.S. forces must be able to adapt in kind—not in decades, as is the timeline of many current processes. However, DOD's lengthy preparation cycles and associated enterprise culture hinder the pace of response that is needed.

This study was charged to help DOD make adaptability a core value—a part of the culture of the enterprise, both its processes and people. The Defense Science Board has identified what it believes are the key elements of a strategy to promote adaptability within the Department of Defense.

- **Align enterprise functions to support mission outcomes.** Couple enterprise functions to mission outcomes by tying deliverables with operational timelines.
- **Reduce uncertainty through better global awareness.** Persistent and deployable teams drawing from all sources, including and especially, open source, rapidly provide contextual understanding of potential global "hot spots" to improve preparedness and agility of response.
- **Prepare for degraded operations.** Institutionalize the use of realistic exercises and red/blue teaming to prepare for uncertain conditions, beginning with two areas of critical importance to nearly all aspects of war fighting—cyber and space.
- **Enhance adaptability of the enterprise workforce.** Broaden awareness and access to the full spectrum of available skills and talent.
- **Change the culture.** Move from a risk-averse to risk-managed approach by employing waiver authority as needed to accomplish mission objectives and conduct follow on analysis of waiver usage to identify and eliminate unnecessary or restrictive processes. Establish a Secretary's Council to resolve problems in meeting the needs of the combatant commanders promptly by using existing resources in new and different ways. Align incentives with objectives and reward adaptability.

In today's evolving and challenging security environment, the ability to adapt will be essential to improving mission effectiveness, with the potential to lead to efficiencies and cost savings. It is the judgment of the Defense Science Board that the Department can and must move beyond cultural, organizational, and regulatory barriers and achieve greater adaptability across the enterprise. The recommendations in this report are important first steps.

Mr. Al Grasso
Co-Chair

Dr. William LaPlante
Co-Chair

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Executive Summary

The world continues to change rapidly. Today's military forces face an increased level of operational uncertainty and must be ready to adapt rapidly. The lengthy preparation cycles and associated enterprise culture and processes that evolved over the past decades are a liability within the Department of Defense (DOD). Solutions must be developed and deployed in days, weeks, or months—not decades.[1] This Defense Science Board (DSB) 2010 summer study was charged to help DOD make adaptability a core value—a part of the culture of the enterprise, both its processes and people.

The DSB has identified what it believes are the key elements of a strategy to promote adaptability within the Department of Defense:

- **Align enterprise functions to support mission outcomes.** Couple enterprise functions to mission outcomes by tying deliverables with operational timelines.
- **Reduce uncertainty through better global awareness.** To improve preparedness and agility of response, establish persistent and deployable teams that draw from all sources, especially open source, to rapidly provide contextual understanding of potential global "hot spots."
- **Prepare for degraded operations.** Institutionalize the use of realistic exercises and red/blue teaming to prepare for uncertain conditions, beginning with two areas of critical importance to nearly all aspects of war fighting—cyber and space.
- **Enhance adaptability of the enterprise workforce.** Broaden awareness and access to the full spectrum of available skills and talent.
- **Change the culture.** Establish a Secretary's Council to resolve problems in meeting the needs of the combatant commanders promptly by using existing resources in new and different ways. Move from a risk-averse to a risk-managed approach by using waivers to identify and eliminate unnecessary or restrictive processes. Align incentives with objectives and reward adaptability.

1. Terms of reference of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces. The complete terms of reference is available at the conclusion of the report.

Align Enterprise Functions to Support Mission Outcomes

The defense enterprise's processes are not aligned well to the rapid pace of today's operational environment. In the ongoing conflicts against counter-insurgency and terrorism in Iraq and Afghanistan, U.S. forces encounter an agile enemy adapting quickly in the tactical arena. Survival requires local response. Success demands rapid response at all enterprise levels. At the tactical level of command, changes in the way forces fight and are supported—in tactics, techniques, and procedures (TTPs) and concepts of operations (CONOPS)—offer one of the fastest responses to an adaptable enemy. It is critical to facilitate proactive and frequent questioning and revision of relevant TTPs and CONOPS. Data show that the overwhelming majority of urgent needs from field commanders are requests for equipment they do not control. The combatant commands, working with the Joint Staff, can **develop a quicker and more effective process to rapidly change TTPs and CONOPS** across units and Services by requiring rapid and distributed collaboration among the users in the field with the help of experienced operators and system developers. Broad and relevant education of expert teams should be assigned to training centers that can teach units how to recognize and implement change and are ready to deploy to operational theaters.

In many instances, TTP and CONOPS adjustments alone cannot adequately address changing circumstances, so new technology or equipment must be introduced. Over the past decade, each military service and the Office of the Secretary of Defense established rapid acquisition activities to accommodate these situations. In fact, more than 20 such organizations exist in the Department today. While many urgent needs were met through the efforts of these activities, problematic elements have emerged. Many are overstaffed, yet in some cases without sufficient domain, technical, or acquisition experience. There are logistics and sustainment challenges with these capabilities once delivered to the war fighter. They also require rapidly available funds, which until now have come largely from supplemental funding to the defense budget. Further, there are no comprehensive plans to institutionalize and/or sunset these many rapid acquisition activities. The key elements to rapidly respond to unexpected operational needs include: be "schedule-driven"; have available authority and funding; be staffed with a small group of experienced people; and have full, senior-level support for obtaining necessary waivers. Each Service should **transition to a single rapid acquisition organization established similarly to the Air Force "Big Safari" program**, with a small, very capable, and experienced staff of 20 to 50 people.

In the case of rapid change to CONOPS and TTPs, or accelerated fielding of technology or equipment, well trained, **field-deployable teams are essential to conduct triage, translate, and fulfill operational commander needs**.

At the enterprise level, current processes tend to focus more on compliance than on outcomes, which means they often fall short of meeting war fighter needs. **Enterprise processes must be aligned to an operational cadence**—the time-phased sequence of events that prepares the force to be operationally ready for a particular mission set. Aligning programs of record to unit deployment creates a shared mission outcome. In addition, the relatively near-term deployment helps limit uncertainty compared to the current 10- to 20-year development cycles.

One key element of establishing this alignment is to **create functional development teams** of key stakeholders (the acquisition officer, resource sponsor, system lifecycle owner, operator, systems engineer, compliance advocate, intelligence, and future operational advocate) at the inception and through the developmental phases of major acquisitions. These teams own the technical and operational intellectual foundation for the systems and provide a venue for the enterprise to engage directly with the operator. In addition, the teams gather important feedback from the field; as the system development matures, requirements can evolve to adapt to the feedback. Also, the important role of the Joint Requirements Oversight Council (JROC) cannot be ignored in this alignment process. The Joint Chiefs of Staff should revise the functions and processes of the JROC to ensure it is supportive of these short development cycles.

An essential role for the teams is to **conduct dynamic trade space analysis** to assess alternative architectures; concepts of operation; and tactics, techniques, and procedures. These teams can guide critical decisions through short development cycles and can motivate their home organizations to support the outcomes most effectively. Tools such as mission rehearsal gaming can help clarify needs and reveal weaknesses early in the development cycle by simulating operational scenarios.

Adaptability can be further enabled by **designing systems with open architecture**—modular concepts, well-designed standards, open interfaces and protocols—so that they can adapt over time to changing environments and new threats. Building systems this way allows them to be upgraded faster, share data more easily, and take advantage of investments of the commercial marketplace. Incremental improvements can be incorporated as they become available, extending the system's lifecycle and enabling it to meet the continually changing needs of the mission.

Another method for enhancing adaptability is equipping the force rapidly by **implementing a block-upgrade strategy**—rapidly fielding 60- to 80-percent solutions and then subsequently enhancing capability. This strategy allows new capabilities to be inserted in a time-phased manner and enables lower risk, lower cost, and faster deployment. Programs, contracts, and budgets can be aligned to support this approach.

The full spectrum of force adaptability must also anticipate strategic futures. While adaptable processes can facilitate changes to TTPs and CONOPS, move existing equipment inventory more quickly to the fight, and realign acquisition processes to be more responsive, some investment should maintain a focus on the longer term to keep options open for uncertain futures and to take steps to shape the future to U.S. advantage wherever possible. **Hedging and shaping strategies are required to manage risk** in a world where it is not possible to invest for all scenarios or to defend against all our nation's threats and vulnerabilities. The Department can benefit from developing strategic investments that will hedge undesirable adversary force developments and steer them to adopt more favorable force postures.

A combination of rapid-response processes and proactive strategies for managing risk and shaping responses will give the DOD more effective, timely, and responsive processes to support mission success.

Reduce Uncertainty through Better Global Awareness

Preparation is a key element of adaptability and the ability of the Department of Defense to ready forces for future conflict.

Maintaining global situational awareness in parallel with ongoing hot wars has proven to be a tremendous challenge. When intelligence resources are drawn to the immediate conflict, the community runs the risk of missing other global indicators of emerging threats. Although the intelligence community eventually achieved superior performance during the two land conflicts in Iraq and Afghanistan, integrated intelligence apparatus was created in the theater, "on the fly" during an ongoing conflict. This *ad hoc* approach delays the establishment of a fully functioning team. There is much room for improvement.

There are three areas in which the Department and the intelligence community could make substantial improvements in preparation, thereby enabling a more adaptable force:

Establishing small, multiagency teams to provide predictive awareness and contextual understanding about regions or problem sets where the U.S. military might need to engage, but that are not currently the focus of intelligence efforts. These teams would act as "first responders" to areas of emerging crises. The capability would comprise four to six core interagency teams trained to work across agency boundaries.

These teams and the Department at large should draw heavily from open source data to provide the foundation for a comprehensive intelligence picture. Though open source has traditionally been undervalued and underfunded, establishment of the Defense Open Source Program Office begins to correct the situation, but the program remains fragmented and understaffed, and it is primarily funded through supplements to the defense budget. The Department must **ensure sufficient funding for open source intelligence collection and analysis to include critical open source intelligence producers, such as the National Media Exploitation Center and the National Air and Space Intelligence Center Special Collections Library**.

Sophisticated threats (actors with intent to do the United States harm) utilize a full spectrum of capabilities to target and exploit DOD information systems and components. The Department must **raise the priority on understanding information system penetrations through the National Intelligence Priorities Framework process** and fill substantial gaps in our nation's understanding of adversaries' full-spectrum capabilities to target DOD information systems. The intelligence community must use the full spectrum of its offensive capabilities to gain understanding of the opposing offense. These efforts should yield deeper insight into the full spectrum of adversary capabilities, as well as their intentions, targets, risk tolerance, key players, key partners, organizational structure, and budgets. In turn, this enhanced insight should enable the community to apply limited resources, identify defensive shortfalls, task collection, inform policy, and inform research. The key is actionable intelligence.

Prepare for Degraded Operations

Even the most adaptable organization can expect to operate in degraded conditions. Degraded operations are those in which the anticipated environment, force capabilities, events, competence, or systems performance depart from plans enough to require unanticipated actions and measures to achieve objectives or to

abort the mission. This study examined training and exercises to prepare for degraded operations at the tactical and operational level.

While training and exercising at the tactical level was found to be generally good with realistic degraded conditions, the study found a serious shortfall in realism at the operational, large-force level. Of the 11 major unified command- and Service-level exercises examined, only one truly incorporated operating in realistic degraded environments as part of its objectives. **Degraded conditions must be included in operational exercises** to train commanders and their staffs to adapt in dynamic and challenging environments.

To further enhance adaptability, **red teaming and blue teaming must be incorporated into development, operational testing, and exercises** to identify weaknesses and corrective actions and develop mitigation strategies. Red/blue teaming continuously explores vulnerabilities associated with DOD plans, operations, concepts, organizations, and capabilities. The teams embody the expertise of both the adversary (red) and the United States (blue). To be effective, a red/blue team must be integrated into a systematic decision-making process at an early stage. Further, successful red/blue team activities have access to robust technical domain expertise, as well as a strong tie to realistic operational exercising. Red/blue teaming within the context of degraded operations is **especially important in the areas of space and cyber systems**, which are particularly vulnerable to potential disruptions. Increased adaptability in mission-essential space and cyber systems is central to successful operations under degraded conditions.

Enhance Adaptability of the Enterprise Workforce

In an unpredictable and changing environment, personnel and organizations that can cope and adapt to unforeseen circumstances will have an advantage. DOD cannot afford to maintain an active duty force with all the skills that might be necessary to operate successfully in a wide range of possible future environments.

DOD needs a mechanism to assess the skills most likely to be required in the future, coupled with a hedging strategy for rapidly leveraging skills and knowledge from the whole of civil society to participate in government teams. An immediate effort must be made to **develop a skills inventory** within the active force, reserve components, government civilians, retirees, and industry. A skills

inventory will enable better identification of shortfalls and better matching of skills to assignments.

Government civilians as well as military and civilian retirees also offer pools of expertise in a wide range of areas that can be tapped by the Department. To better access individuals with relevant specialized skills, the Service secretaries should **accelerate the use of existing hiring authorities** to bring skilled individuals from civilian life into the government—authorities such as the Civilian Expeditionary Workforce, National Language Service Corps, Intergovernmental Personnel Act, and Highly Qualified Expert authority.

In addition, much work needs to be done by the Department to develop strategies to **screen for adaptability** as an aid in recruitment, to train individuals to be more adaptable, and to ensure that organizations use adaptable people to cope with unforeseen circumstances—all of which will aid in enhancing the adaptability of the DOD workforce.

Change the Culture

The objective of an adaptable Department of Defense is to prepare the enterprise to be effective in an uncertain environment. Achieving the level of adaptability demanded by today's challenges will require a major transformation that spans many aspects of the Department's operations. Achieving the desired outcomes will also require explicit steps to instill adaptability as a core value and shift the culture from one of risk aversion to one that emphasizes outcome, risk management, and efficiencies in how the Department operates.

Culture change begins at the top. The DSB recommends that the Secretary of Defense **establish a Secretary's Council**, comprising the Service secretaries, to ensure that the vast array of enterprise resources that they command is responsive to the needs of the theater on a joint basis. The Service secretaries oversee both the civilian and military components of their respective military departments. These responsibilities, coupled with their political relationships with Congress, would empower them to tackle the intractable problems that make it to the Secretary's Council. The council will recognize that increased agility is required during times of hot war and will model the value of leveraging all resources to achieve a shared mission outcome.

Culture change can be accelerated by putting the proper incentives in place. One important reason that DOD lacks crisp execution of its processes is that incentives—

for individuals, organizations, and contractors—do not align with mission needs. The DSB recommends that the Department leadership recognize the incentives that are driving organizational and personal performance and take action to **better align those incentives with DOD national security objectives**. Meaningful annual performance reviews should be conducted at every level and appropriate actions taken based on achieving performance objectives. The goals set by the Secretary and the Chairman, Joint Chiefs of Staff should be visible to all.

One of the key attributes of successful commercial organizations is their willingness to abandon processes that consume resources but do not create value. Congress has granted the Department significant waiver authority in many areas, but the Department has been historically reluctant to use it. **Use of waivers** is an area in which culture change is needed. The current culture of risk aversion means that "no" is a much more common answer than "it can be done." All the under secretaries of defense, working in conjunction with the DOD General Counsel, should collaborate to streamline the waiver approval process, raise awareness of how waivers can be used, and identify frequently waived regulations, policies, and statutes that should be changed or eliminated.

Summary

The aim of the recommendations presented in this report is to increase adaptability in the Department of Defense in order to improve mission effectiveness. We believe that in today's evolving and challenging security environment, the ability to adapt will be essential to success. Further, changes proposed throughout this report not only will dramatically improve mission effectiveness in DOD but also will have the potential to lead to efficiencies and cost savings. We believe that such changes are within the Department's reach and that the actions identified in this report are important first steps.

Summary of Key Recommendations

What	Who	Why	When
Align Enterprise Functions to Support Mission Outcomes			
Align programs of record with block delivery approach to unit deployment schedules; establish functional development teams; employ dynamic trade space analysis and open architectures	USD (AT&L) and service acquisition executives	Create shared mission outcome and sense of urgency; enable timely delivery of capability to the war fighter	POM 12 Planning Cycle
Enable more effective rapid response: rapid acquisition, TTPs, CONOPS, in-field modification	Joint staff; USD (AT&L); service acquisition executives	Provide more timely response to war fighter needs in unanticipated circumstances	2011
Develop hedging and shaping strategies for strategic planning	USD (AT&L); service acquisition officers	Manage risks in an uncertain future	POM 12 Planning Cycle
Reduce Uncertainty through Better Global Awareness			
Establish small, multi-agency teams to provide predictive awareness about regions where the U.S. might need to engage	USD (I), DNI	Maintain global situational awareness even in the presence of ongoing conflict	2011
Make better use of open source intelligence	Director, DIA, with DIOSPO and ODNI Open Source Center	Address intelligence gaps and increase actionable output	2011
Raise the priority on understanding DOD information system penetration	Director, NSA and the National Intelligence Officer for Science and Technology	Achieve better understanding of adversaries' full-spectrum capabilities to target DOD information systems	Dec 2010
Prepare for Degraded Operations			
Create more realistic degraded training environments; focus on cyber and space operations	Services' training commands	Realistically emulate degraded environments; enable war fighters to adapt in the face of dynamic environments	2011
Establish red and blue teaming in operational testing and exercises	Combatant commands and Services	Identify weaknesses and vulnerabilities; develop corrective actions	Dec 2010
Develop back-up plans and mitigation approaches for degraded cyber and space operations	Chairman, Joint Chiefs of Staff	Address vulnerabilities and prepare to respond to disruptions	Dec 2010
Devise cyber security key performance parameters	USD (AT&L)	Develop programs that provide enhanced cyber and space situational awareness	March 2011
Establish behavioral health care detachments at the battalion level, provide resiliency training, and monitor individual performance	Services	Increase behavioral health and psychological resiliency	Dec 2010

Summary of Key Recommendations (continued)

What	Who	Why	When
Enhance Adaptability of the Workforce			
Determine needed skills and identify methods to acquire them; accelerate use of existing hiring authorities	USD (P&R)	Prepare for an unpredictable and changing environment; increase the Department's ability to deploy people efficiently	Strategy within 6 months; databases within 2 years
Assess adaptability in individuals	USD (P&R)	Predict individual performance in the field	2011
Incorporate adaptability into career management	Secretary of Defense	Reward personnel who demonstrate adaptability	Within 6 months
Change the Culture			
Establish a Secretary's Council	Secretary of Defense	Provide increased agility during times of "hot" war; leverage all resources	Immediate
Analyze waiver experience data	USD (AT&L) and General Counsel	Identify processes that are candidates for changing regulations, policies, or statutes	2011
Align incentives with DOD national security objectives	Department leadership	Drive organizational and personal performance	2011

Chapter 1. Adaptability

Adaptability must be a key determinant of what the Department of Defense (DOD) buys, how it trains and develops personnel, how it develops intelligence, and how it operates. Too often, force adaptability relies on a few innovative individuals who, in the heat of a crisis, create an inefficient but effective work-around to accomplish the mission. While sustaining and encouraging such individual innovation is a good idea, it is equally important to examine what the DOD can do more broadly to enhance both the degree and the cycle time of adaptation.[2]

When one considers an adaptable organization, one often thinks of the responses of a biologic system adapting to changes in its environment through the mechanism of evolution. However, despite the wondrous changes wrought by natural selection, evolution is a slow, random process that has no mechanism to anticipate future changes. A truly adaptable system, on the other hand, should predict future changes in its environment, rapidly sense when those changes occur, and be able to modify its capabilities (or reshape its environment) in near real time. How well an organization (like DOD) can truly adapt to an ever more rapidly changing environment will determine its fundamental ability to execute its strategic vision.

The top level objective of this study was to help DOD make adaptability a core value—a part of its "DNA." To define what is meant by adaptability, a variety of case studies and descriptions were considered—from Mahatma Ghandi to Peter F. Drucker to Secretary of Defense Robert Gates to Admiral Michael G. Mullen, and many others. For much of the study, the consensus definition adopted for adaptability was "**the ability to bring about timely and effective adjustment or change in response to the surrounding environment**." During the course of the study, however, it became evident that while this view of adaptability may be necessary, it is not sufficient. It is as important for an adaptable organization to prepare for change as it is to implement change. Thus a more complete definition of adaptability is "**the ability and willingness to anticipate the need for change, to prepare for that change, and to implement changes in a timely and effective manner in response to the surrounding environment**." This report will utilize this more complete definition of

2. Terms of Reference of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces. The complete terms of reference is available at the conclusion of the report.

adaptability to explore what steps DOD should pursue to become truly adaptable and to offer actionable recommendations.

It has been repeatedly demonstrated that DOD's deployed forces routinely adapt extraordinarily well at the tactical levels. This study encountered numerous stories from tactical operations in Iraq and Afghanistan of impressive adaptation, ranging from prolific use of unmanned aerial vehicles to the use of social networking tools, such as companycommander.com, to share information, experience, and lessons learned.

War fighters adapt because their lives depend on it. Leadership creates and disseminates strategic, operational, and tactical objectives that are shared throughout the war fighting community. War fighters understand that the objectives are time-sensitive and, therefore, develop a shared sense of urgency. America's cultural background tolerates, even encourages, innovative and adaptive behavior. It is a natural part of our nation's culture and can be viewed as a distinct advantage from other cultures. However, in the military enterprise, the impetus to adapt becomes less urgent and far less shared as one is removed from the battlefield. The threat of death and bodily harm that focuses the war fighter on clearly stated mission objectives is replaced by a cacophony of voices and priorities—among which are compliance, budget, and incoherent guidance.

Unfortunately, the DOD enterprise functions that support the war fighter have evolved over time to be resistant to change and rely heavily on approved processes. While some examples of successful adaptation exist at the enterprise level in the Department of Defense, each is an exceptional case, celebrated for being a departure from the norm instead of being the norm.[3] Even at the operational level, adaptations are limited to a few isolated examples, such as the Army Mobile Parts Hospital and U.S. Special Operations Command's Mobile Technology Complex initiative, which have moved forward critical support functions to increase speed of response to urgent needs.

The contrast in DOD between valued attributes of the operating tactical forces and the enterprise processes is quite striking, as portrayed in Table 1-1. Impediments to a more adaptive DOD, especially among its enterprise elements, can be better understood by examining successful adaptive organizations in the commercial sector. (Additional detail is contained in Appendix A, which describes many commercial and DOD case studies.)

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3. The acquisitions and deployments of the F-16, F/A 18 E/F, Acoustic Rapid COTS Insertion (ARCI), Advanced Medium-Range Air-to-Air Missile (AMRAAM), and Army Digitalization can all be cited for adaptability (Appendix A).

Table 1-1. Differing Attributes of Tactical Forces and the Enterprise

Attribute	Tactical Forces	Enterprise
Doctrine	Plan and act according to a field manual or statement of concept of operations	Plan and act according to the Planning, Programming, Budgeting and Execution System; Federal Acquisition Regulation; Defense Federal Acquisition Regulation; congressional language; and other guidance
Relationships	Operation at the "speed of trust"; always looking for ways to make it work, success linked to transparency, full focus on mission outcomes	Competition vice cooperation, process governs speed; always easier to say "no," little accountability to mission outcomes
Red teaming	Used to understand and prepare for adaptability before the fight	Underutilized as planning and execution tool
Experiments	Used to discover and understand possible futures	Used to demonstrate mostly-known systems
Exercises	Used to provide immersive training and to practice adaptation	No equivalent approach
Training	Adaptability stressed in classroom and immersive training	Rigorous adherence to process stressed in training
Incentives	Aligned with mission objectives	Aligned with process objectives

Adaptive Commercial Organizations

A review of recent literature and interviews with industry leaders identified a set of characteristics for adaptive organizations. Figure 1-1 presents a framework for organizational adaptation that emphasizes alignment of vision and strategy, culture and beliefs, processes and plans, people, and outcomes—outcomes being products and services in commercial organizations.

Organizations with such alignment possess a shared sense of urgency from top to bottom to produce relevant outcomes.[4] The people within the organization understand how their work contributes to outcomes, share a sense of responsibility

4. Ionut C. Popescu. "The Last QDR? What the Pentagon Should Learn from Corporations about Strategic Planning," *Armed Forces Journal*, March 2010.

for those outcomes, know how they are held accountable for those outcomes, know that their management supports their efforts to achieve the outcomes, and know that time is essential. In short, the entire organization is motivated to achieve and is focused on timely outcomes that make a difference for their primary customer—which in DOD's case is the war fighter. In such organizations, those who say "no" without authority or accountability are not tolerated, and innovative change leading to product and/or process improvement is highly valued. These organizations are also grounded in a culture with core values that encourage continuous examination of how work is done and how to improve.

Figure 1-1. A Model for Organizational Adaptation

In a commercial setting this means achieving and sustaining a competitive advantage in the marketplace. Such organizations have senior leadership that consistently and effectively communicates the vision and strategy (why the organization does what it does) and a culture that is congruent (a shared set of beliefs about what elements of the vision and strategy are important). With this alignment of strategy, vision, and beliefs, it becomes possible for personnel within the organization—at all levels—to develop processes, plans, products, and services that are focused on achieving shared outcomes in a timely manner.[5]

The commercial world has faced—and often met—many of the adaptability challenges facing the Department of Defense today. After looking at the many

5. William B. Rouse. "A Theory of Enterprise Transformation," *Systems Engineering*, 2005 8:279–295.

examples of adaptive commercial companies, as well as some less adaptive examples, key attributes can be distilled. The attributes that distinguish successful adaptability in commercial culture, listed below, shape many of the study's specific recommendations. Few are routinely deployed in the Department today.

- **Leadership frequently and consistently communicates the vision and strategy.**[6] The Ford Motor Company recovered from its losses by establishing a "one Ford" strategy, with a focus on maintaining a competitive advantage in the marketplace, and communicating that strategy at every opportunity.
- **Fast, good decisions are sought and acted on.**[7] Cisco, one of the most valuable companies in the world, emphasizes early value delivery with an approach called "rapid iterative prototyping" and staffs projects with people who are capable of learning and adapting.
- **Smaller teams are favored for their higher productivity.**[8] Google has an average of three engineers per team to encourage experimentation, remain adaptive, and retain a small company feel.
- **Innovation is expected and supported; people are willing to experiment and learn.**[9] Novell, a multinational software and services corporation, increased sales by 30 percent and doubled profits by changing its culture and involving employees in product development.
- **Individuals are valued—new ideas and challenged assumptions are encouraged throughout the organization.**[10] Intel, the world's largest semiconductor chip maker, maintained strong brand value in the face of relentless competition by knocking down the barriers between research and development (R&D) and manufacturing.
- **A unique and sustainable advantage is sought through achievement, innovation, and change.**[11] Amazon.com became America's largest online retailer because of its willingness to make changes, both large and small, while others were just catching up.

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6. Alex Taylor III. "Fixing Up Ford," *Fortune* Magazine, May 12, 2009. http://money.cnn.com/2009/05/11/news/companies/mulally_ford.fortune/ Accessed October 20, 2010.
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9. Gary Hamel. "Outrunning Change - the Cliff Notes Version," *Wall Street Journal,* October 21, 2009. Available at http://blogs.wsj.com/management/2009/10/21/outrunning-change-the-cliffsnotes-version/ Accessed August 30, 2010.
10. Ronald A. Heifetz and Marty Linsky. "Practice of Adaptive Leadership: Tools and Tactics for Changing Your Organization and the World," *Harvard Business Press*, 2009, p. 169–170.
11. Eric D. Beinhocker. "The Adaptable Corporation," *The McKinsey Quarterly*, 2006, No. 2, pp 76–87.

- **Work is output- rather than input-centric; it begins by stating desired outcomes in customer terms, and then seeks a portfolio of executable options.**[12] Apple's dominance in the consumer electronics market is attributable to its strategy of value creation and starts by asking the question "What do customers need?" Importantly, Apple holds firm to this outcome vision of its products from the initial design concept through engineering and manufacturing.
- **Information is widely available and processes are transparent.**[13] Apple establishes cross-functional teams and gives them responsibility and authority.
- **Customer satisfaction, cost, and schedule trade space is addressed with a sense of urgency and focus on shared outcomes.** Cemex grew from a small local building materials company to one of the top global companies in the industry by understanding customers' mindset and focusing innovation on how the work is done and delivered to the customer.[14] Cemex equipped its truck fleet with GPS locators, enabling dispatchers to arrange deliveries within a 20-minute window as compared to the three hours that competitors require.
- **Block upgrades and standard platform approaches are utilized.** Qualcomm, the leading wireless semiconductor supplier in the world, uses open source platforms and software environments to accelerate block upgrade functionality enhancements.
- **Processes, training, education, incentives, and accountability are aligned with strategy, vision, and culture.**[15] Southwest Airlines, the largest U.S. carrier, views its people as its major differentiator and invests heavily in training to ensure companywide commitment to its mission.
- **Activities that consume resources but create no value for the customer are routinely challenged and eliminated.** IBM routinely adapts to the changing business climate by shedding old products and developing new capabilities. In the past few years, IBM shifted from mainframe computers to the personal computer market, and again to focus as a service provider—resulting in one of the largest and most profitable information technology companies in the world.

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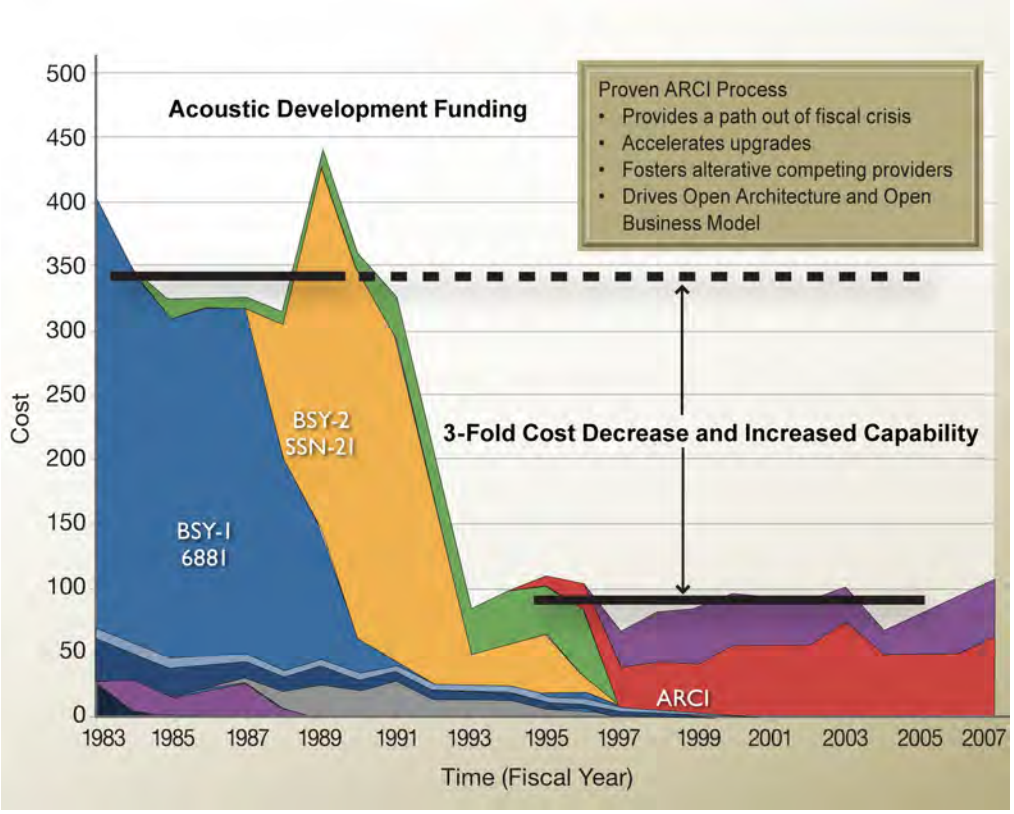
12. Lev Grossman. "How Apple Does It," *Time*, October 16, 2005, pp. 66–70.
13. Thomas J. Peters and Robert H. Waterman, Jr. "In Search of Excellence: Lessons from America's Best Run Companies," *Harper Business*, 1982, 2004.
14. John P. Kotter. "What Leaders Really Do," *Harvard Business Press,* 1999, p. 76–77.
15. Bill Ahls. "Organizational Behavior: A Model for Cultural Change," *Industrial Management*, 2001, 43(4) pp. 6–9.

Comparisons to DOD

The attributes of successfully adaptive organizations are not exclusive to commercial companies. A number of examples illustrate that DOD has the ability to be adaptable, but typically these are isolated cases—not best practices that have been implemented or adopted across the enterprise. As an example, the Navy found itself in the early 1990s with a significant problem. Defense budgets were under pressure at a time when the Navy's submarine force did not have the capability to detect an emerging threat, and it took over $300 million per year to support the BSY-1 and BSY-2 sonar processing suites. It also took twelve years, on average, for the development and deployment of each new capability.

Confronted with the challenges of acoustic quieting in world-wide submarines, the Navy initiated the Acoustic Rapid COTS Insertion (ARCI) program to dramatically accelerate the introduction of technological advances and overcome the challenges of reduced funding by rapidly procuring commercial off-the-shelf (COTS) hardware and software. The program launched a new way of doing business by using a capabilities-based process versus a requirements-based process, and by employing an open system using commercial standards. The Navy defined the architecture in a way that allowed *partitioning* and *continuous competition.* The program involved multiple defense contractors, laboratories, and program office personnel and was counter-cultural and politically difficult for the leaders to sustain. The results were dramatic and pioneered much of the open architecture work that has been done to date.

Results of the program reduced the Navy's acoustic development funding needs by a factor of three (Figure 1-2). The technology insertion cycle was shortened from 12 years to 2 years for software, and 4 years for hardware. The added processor cycles were used to develop improved software algorithms that extended the capabilities of the legacy sensors on the platform and met the requirements of the new threat. Immediate feedback from post-deployment evaluations of algorithm performance contributed to developing next-generation capability. The architecture encourages continuous innovation and competition and continues to operate effectively today, more than fifteen years after the start of the program.



Note: SSN upgrade—12 year average; ARCI tech insertion: software every 2 years, hardware every 4 years

Figure 1-2. Navy Submarine Force Benefits with ARCI

Between 1997 and 2004, the processing capability enabled by the open architecture in ARCI improved 12 times and the cost per processing cycle was reduced 50 times. Through innovative and courageous leadership, the Navy's submarine sonar community made the ARCI program a success and used it to create a path out of a fiscal crisis. The resulting system improved performance faster than traditional methods and dramatically reduced cost. The flexible, open architecture has allowed the system to continually adapt over time and the program remains viable and innovative today.

Unfortunately, the less than successful DOD examples cover a wide spectrum of capability. For example, the VH-71 Kestrel Presidential helicopter is illustrative of problems that plague many DOD acquisition programs. The VH-71 was planned as the replacement for the U.S. Marine Corps One Presidential transport fleet. The program faced steep engineering challenges, continual expansion of requirements within a compressed time schedule, and poor communication between the

contractor teams and the government teams.[16] Significant cost overruns ultimately resulted in the contract's termination and much negative publicity. These conditions are cited in numerous U.S. Government Accountability Office (GAO) reports investigating acquisition failures.

In another example, the Department found its foreign language capability ill-prepared for the 21st century due to a poorly focused emphasis on Cold War languages, and no emphasis on potential hot spot languages. The Department has been playing catch up following the events of September 11, 2001. One of its most successful efforts resulted from a onetime survey of its members that resulted in a dramatic increase in its known language capability. (See Appendix B for more discussion of the development of DOD's foreign language expertise.)

Comparisons with commercial organizations reveal several distinct differences between the DOD and commercial organizations. First, the commercial world often enjoys longevity in leadership that DOD does not. Academic and case studies agree that five to seven years are needed to achieve cultural change.[17] The rapid and many times predictable timelines for leadership change in DOD have resulted in a culture that can "wait out" such initiatives. Second, commercial governance tends to be less fragmented than the leadership in DOD. Politics and administrative cycles lead to inherent decentralization, despite a strong Secretary of Defense at the top. Finally, DOD incentives are largely compliance-driven—rather than results-focused—which leads the Department too often to optimize around process rather than around delivering capability to the war fighter.

The ability to innovate in peacetime and adapt during wars requires institutional and individual agility. This agility is the product of rigorous education, appropriate application of technology, and a rich understanding of the social and political context in which military operations are conducted. But above all, innovation and adaptation require imagination and the ability to ask the right questions and represent two of the most important aspects of military effectiveness.[18]

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16. For further discussion see: *Report of the Defense Science Board Task Force on Integrating Commercial Systems into the DOD, Effectively and Efficiently*, *Buying Commercial: Gaining the Cost/Schedule Benefits for Defense Systems*, February 2009. http://www.acq.osd.mil/dsb/reports/ADA494760.pdf
17. U.S. General Accounting Office, *Results-Oriented Cultures: Implementation Steps to Assist Mergers and Organizational Transformations*, GAO-03-669, July 2003, p. 9.
18. Department of Defense. *The Joint Operating Environment 2010*, p 72. Available at http://www.jfcom.mil/newslink/storyarchive/2010/JOE_2010_o.pdf. Accessed August 30, 2010.

In summary, adaptive organizations are innovative, and this trait is embedded in their culture and encouraged by their leadership. All adaptive organizations have a critical component for change: a shared sense of urgency to succeed. In adaptive organizations, processes, incentives, training, and accountability are strongly aligned with strategy, vision, and culture, and focused on outcomes meaningful to the organization's customers. This alignment and focus on outcomes has an unwavering commitment at the top. For the purposes of this study, these key attributes are as important to successful war fighting as they are to successful commerce.[19] And they are fundamentally critical if the DOD enterprise is to become more adaptable and, in turn, provide more timely support to the war fighter.

Methodology of the Study

Many paths exist to achieve increasing adaptability, and a broad spectrum of options is available, from workforce development to improving adaptability of systems to streamlining management processes. Delivering adaptable, enabling capabilities depends on people being skilled at quick and correct decision-making. Systems and equipment that are specifically designed and built to be adaptable provide the needed flexibility for successful accomplishment of whatever mission is encountered. Equally important are management processes that provide the needed flexibility, funding, and incentives to enable quick response.

This study revealed five overarching themes to achieving systemic adaptability:

- **Align enterprise functions to support mission outcomes.** Couple enterprise functions to mission outcomes by tying deliverables with operational timelines. Reconcile conflicting trades with methods used in the private sector. Empower functional development teams to conduct dynamic trade space analyses and red teaming to enable mission success.
- **Reduce uncertainty through better global awareness.** Persistent and deployable teams drawing from all sources, especially open source, rapidly provide contextual understanding of potential global "hot spots" to improve preparedness and agility of response.
- **Prepare for degraded operations.** Institutionalize the use of realistic exercises and red/blue teaming to prepare for uncertain conditions, beginning with two areas of critical importance to nearly all aspects of war fighting—cyber and space.

19. Williamson Murray. *Military Adaptation in War,* June 2009, IDA Paper P-4452, pp. 8-4 to 8-10.

- **Enhance adaptability of the enterprise workforce.** Broaden awareness and access to the full spectrum of available skills and talent.
- **Change culture.** Establish a Secretary's Council to resolve problems in meeting the needs of the combatant commanders promptly by using existing resources in new and different ways. Move from a risk-averse to risk-managed approach by using waivers to identify and eliminate unnecessary or restrictive processes. Align incentives with objectives and reward adaptability.

The remainder of this report serves as a roadmap to move the Department toward a future state of greater adaptability. Chapter 2 begins with an historical perspective on adaptability in DOD, focusing on how processes have evolved largely in response to the Cold War security environment, which in today's world prevents rather than promotes adaptability. Based on this understanding, Chapters 3 through 7 examine each of the five overarching themes outlined above, offering specific recommendations in each area.

Chapter 3 explains how DOD processes should be realigned to better support war fighting needs across all relevant timeframes. Chapter 4 discusses a means to keep the intelligence community focused on important long-range security trends and potential conflicts and/or adversaries that will reduce the need for pick up teams to support deployed forces and will inform long-range planning. Chapter 5 describes the role that exercises and red/blue teaming play in anticipating potential counters to U.S. capability—a process that should feed back into new, more rapid cycle times for system deployment. Chapter 6 examines the knowledge and skills needed to grow the Department's capability to adapt and how to acquire those skills. In conclusion, Chapter 7 examines the importance of culture change in implementing the recommendations put forth throughout the report, and provides guidance for accelerating change within DOD.

Chapter 2. What Prevents Adaptability in DOD: An Historical View

In early 2009, the Chairman of the Joint Chiefs of Staff stated that "The future operating environment will be characterized by uncertainty, complexity, rapid change, and persistent conflict."[20] The rate of change in defense system capabilities is shown graphically in Figure 2-1. While large platforms like carriers and bombers remain in service for decades, software intensive systems change very rapidly, often motivated by evolving adversary capabilities—as in countermeasures to improvised explosive devices (IEDs)—or by rapidly changing technology. A myriad of other system capabilities and infrastructure fall in between.

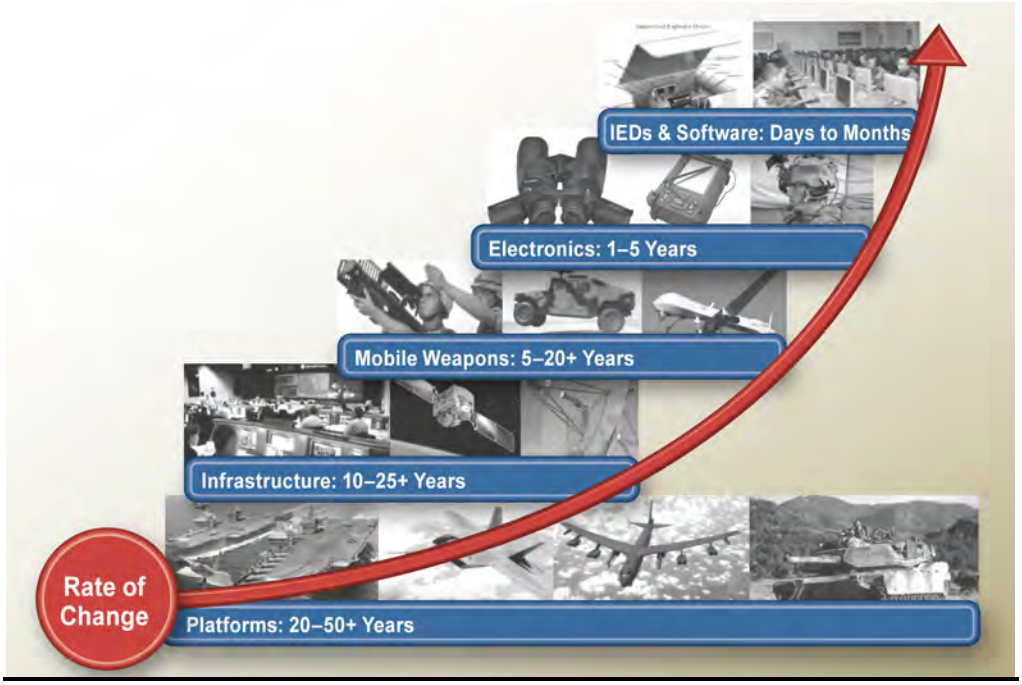


Figure 2-1. Rate of Change in Defense Systems[21]

To be prepared for success in this uncertain, complex, and rapidly changing operating environment, the Department of Defense must be able to adapt rapidly,

20. *Capstone Concept for Joint Operations*, January 15, 2009.
21. Systems Engineering 2020 Briefing, July 23, 2009.

effectively, and affordably across the spectrum of its systems and their employment. Yet, the fact is that DOD's processes are complex, time-consuming, and often do not align well with the timeframes dictated by today's operational environment. For example, the complexity of the current traditional planning and lifecycle management approach defined by DOD Instruction 5000.2, and depicted in Figure 2-2, does not easily accommodate the broad spectrum of DOD systems and their need for rapid change and adaptation. In contrast, Figure 2-3 shows a streamlined service acquisition process from a world-class, global manufacturer. Unlike DOD 5000.2, this commercial process is focused on meeting time-sensitive, service-critical, unpredictable demands from a world-wide customer base and is supported by flexible contracting practices.

Success in enabling systemic adaptability will require shedding complex and non-value added processes to better align the enterprise with the Department's operational forces. It will also require recognition that enterprise culture and processes are still rooted in, and responsive to, a largely Cold War context and mentality. **It is the judgment of the DSB that the Department can and must move beyond these cultural, organizational, and regulatory barriers and achieve greater adaptability across the enterprise.**

An obvious question is why adaptability is so difficult for the Department of Defense. Some answers can be found in the Department's Cold War history and legacy in which very long planning, training, personnel, and acquisition cycles were reasonably matched to a well-understood threat environment.

The Cold War

For several decades after World War II, the Department of Defense built organizations and capability to confront a well-understood peer Soviet threat. As the Cold War progressed, the operative generation time available to prepare for an unspecified future confrontation encompassed the range from essentially infinite—enabling the development of large and increasingly complex platforms designed to perform their functions for many decades—to amazingly short, measured from minutes for nuclear response, to hours or days for stopping the Soviet invasion of Europe (*e.g.*, Fulda Gap).

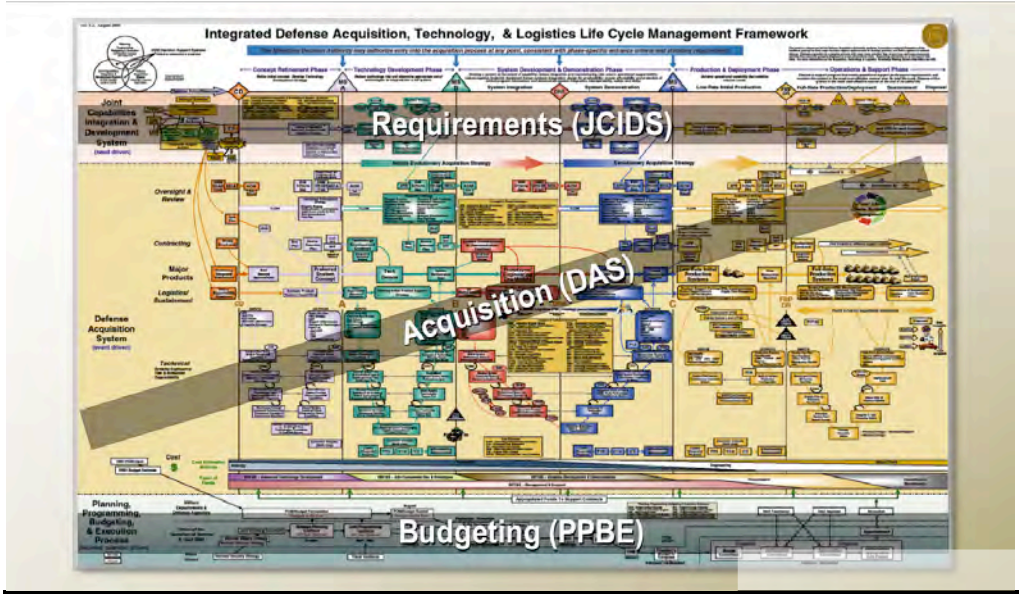
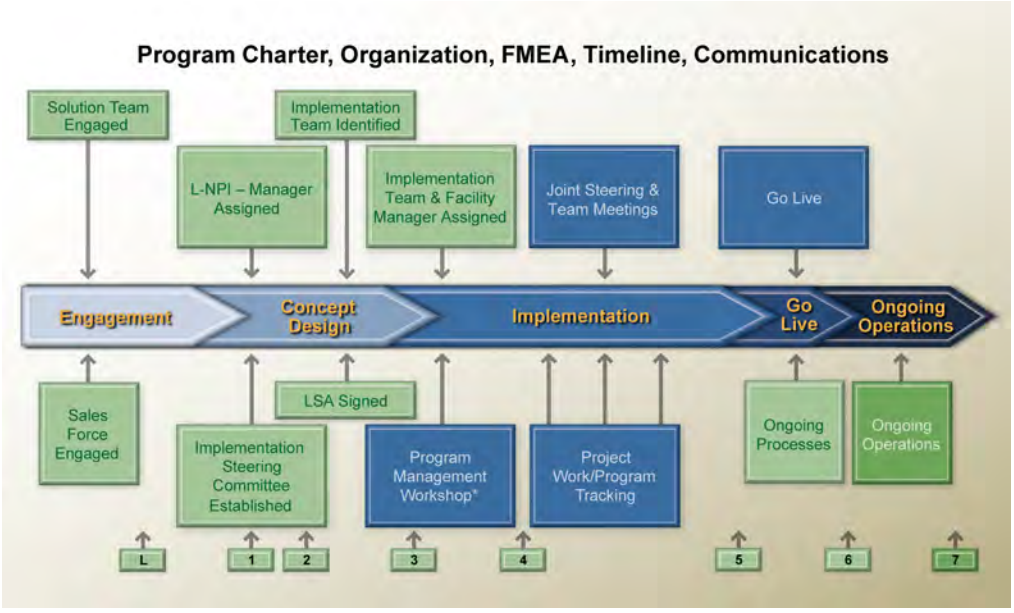


Figure 2-2. The Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System, Version 5.3.3.



Source: Caterpillar Logistics Services, Inc.

Figure 2-3. Industry Acquisition Process

Operational ground and air forces were permanently garrisoned in Europe and around the world as part of the Cold War containment strategy. Intelligence capabilities concentrated on "order of battle" and providing sufficient strategic warning to allow U.S. forces to flow to Europe in time. Focus was on long, predictable evolutionary change against a Cold War peer opponent who suffered as much, if not more, than the United States from a rigid and bureaucratic system. There were certainly instances of adaptability during the Cold War period, but the surviving features of that period are now predominated by long compliance-based structures.

Figure 2-4 illustrates the long and deliberate enterprise planning cycles focused on the well-defined capabilities needed to confront the Cold War threat. The Cold War environment focused on a peer competitor and the existential threat posed by its nuclear capabilities. The enterprise provided a level of readiness to deal with the specific threats, which typically followed long timelines and included long cycles of preparation aimed at acquiring new systems, training on those systems, and performing operational exercises. The execution phase would have been very short and focused on slowing the conventional forces long enough for the U.S. strategic reserve to engage. In the relatively stable Cold War environment, particularly in the later stages, there was relatively little need for adaptation time cycles measured in days or months. It should be noted that on a much smaller scale, special operations activities were shaping the environment through covert, but deliberate, engagements. These small-scale activities, much like current day operations, illustrate the enduring adaptability of highly specialized, tactical forces.

The United States crafted several military strategies over the course of the Cold War to counter the Soviet Union. Throughout the Cold War, defense doctrine assumed that any other potential conflict would be captured by the extant strategy. This approach arguably prevented a third world war and nuclear devastation during conflicts in Korea and Vietnam, and resulted in post Cold War successes in the Balkans and Iraq in the 1990s.

During the extended Cold War period, the DOD enterprise developed a myriad of functions (*e.g.,* planning, budgeting, requirements, acquisition, testing, training, personnel, intelligence) to implement its strategies. The risk horizon—the uncertainty of future challenges both in terms of projected years into the future and the spectrum of risk at a given time—was constrained for decades. Complex compliance-based processes were exercised to minimize mistakes with little regard for impact on schedule or cost.

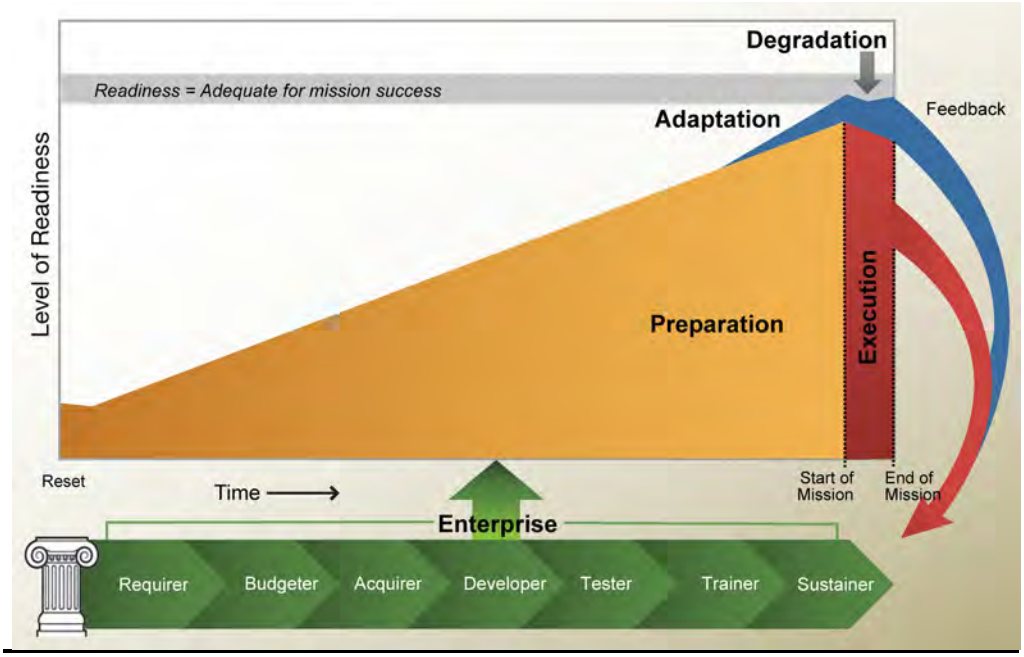


Figure 2-4. Cold War Enterprise Cycle

Compliance with the many steps in these processes hindered adaptability. In a trade space of schedule, cost, and performance, schedule was often the first sacrificial offering, quite often followed by cost. Although cost and schedule overruns generated significant criticism, the impact was moderated by the potential existential threat. And the relatively static nature of the Cold War was slow to distinguish disruptive features of fielded systems. Following the demise of the Soviet Union, most of the driving force to maintain some competitive edge dissipated. Over time the enterprise functions hardened into stodgy, compliance-driven processes with diminished capabilities for adaptability more focused on following rules with little attention to produce desirable outcomes.

While the United States engaged the Soviet Union in the Cold War, the commercial marketplace transformed from a planning-centric industrial base model to an information-based "sense and respond" model in order to be competitive in an uncertain and rapidly changing global environment. Richard Nolan and Larry Bennigson describe the transition to the Micro Era as enabling workers to rapidly obtain and manipulate figures, previously available to only select individuals in the firm. Consequently, the incremental business model showed more erratic business

performance than the incremental earnings per share "march to the Northeast corner" of the earlier industrial-based model.[22]

New technology companies emerged and many commercial markets grew to dwarf defense markets. Diminished defense science and technology initiatives, once a massive engine of the U.S. economy, are now a nominal percentage of most information-based commercial industries and the U.S. defense industry no longer controls important segments of cutting edge technology. The tremendous global expansion of the commercial market allows anyone access to commercial technology which, if imaginatively applied at the speed of the commercial market place, could be pursued to offset U.S. military capability.

New businesses emerged to address the insatiable global appetite for information as did new means of communications leading to expanding social and business networks. By the end of the 20th century, the Information Age extended communications and networking to people around the world. Although DOD exploited some aspects of this revolution to its advantage, the Information Age also created tremendous vulnerabilities.

The military industrial base in the United States, reasonably vigorous into the 1980s, was forced to consolidate into a handful of large system integrators after the fall of the Berlin Wall. The large system integrators mirror the DOD practices and continue to deliver military capabilities structured to serve DOD at its enterprise pace. Of course adversaries are not bound by U.S. cost imposing and compliance practices, and can acquire capability much cheaper and faster on the global market.

While the economic landscape evolved, the end of the Cold War changed the geopolitical world almost overnight. The threat environment suddenly shifted from well-defined and understood to vague and expansive. Two populous nations, China and India, became new centers of manufacturing and software development. Their growing populations, coupled with new economies consume ever increasing amounts of natural resources, energy, and manufactured goods. The growing global competition for natural resources (*e.g.*, oil, fresh water, ores) and export base products (*e.g.*, steel, electronics, and consumer goods) stress the U.S. economy, environment, and national security.

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22. Richard Nolan and Larry Benningson. Harvard Business School Working Paper # 03-069, *Information Technology Consulting*, 2002.

New adversaries emerged who interpreted the spread of capitalism and democracy as a threat to their individual or collective goals and aspirations. Many are associated with nation states—North Korea, Iran, Venezuela—and others align with non-state groups often tied to radical Islam. Global communications allow these adversaries to study U.S. strengths and understand weaknesses. Adversaries are able to exploit this knowledge in a variety of ways (*e.g.*, obtaining commercial capability in the globalized market, clandestine proliferation of nuclear weapons technology, manipulating public opinion). Thus both resource-poor states and non-state actors can obtain capabilities that challenge U.S. strategic interests.

In addition, many militarily-relevant capabilities have become commoditized, with components that can be bought commercially around the world and integrated rapidly at relatively low expense by potential adversaries. At the same time, traditional DOD processes continue to be mired in compliance practices and political disagreements. As a result, the nation's adversaries have an ability to work faster than is possible within the constraints on DOD. While the *Joint Operating Environment* produced by the Joint Forces Command and its companion document, the *Capstone Concept for Joint Operations*, both recognize these changes, the supporting broad DOD enterprise has not systematically recognized them and therefore has not adapted as readily.

Today's Changing World

The world today continues to change rapidly. In response, DOD must develop an adaptive culture to succeed in these uncertain times. The lengthy preparation cycles enjoyed by DOD in past decades are a liability. Rapid response processes and organizations bypass conventional means to develop, deploy, upgrade, and replace systems, subsystems, personnel, and information in far shorter timeframes. Some technology to combat IEDs and many software systems are developed and deployed in days, weeks, or months. Mobile weapons platforms are tilting toward 3- to 5-year development cycles versus the 10- to 20-year cycles of the past. The Department engages personnel practices to hire expertise unavailable through the normal civil service process. Strategic knowledge can be formed outside of formal intelligence community channels. As depicted in Figure 2-5, operational forces have come to rely on very rapid processes to maintain their competitive edge while faced with shifting threats and rapidly adapting adversaries. Information systems can now suffer significant degradation during preparation and execution, creating a need to rapidly adapt or face significant operational degradation. In some cases the enterprise can keep up with the new time cycle of the operational forces. In many cases it does not.

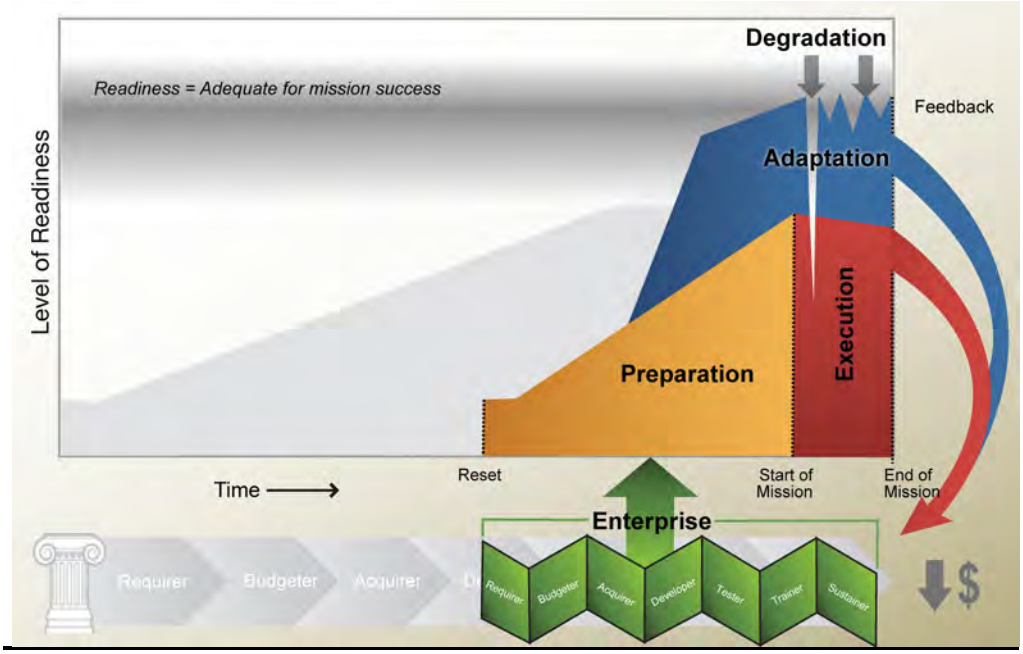

Figure 2-5. Modern Day Enterprise Cycle

The contrast between Figures 2-4 and 2-5 readily illustrates that preparedness and readiness are inextricably linked and the enterprise must become matched to the shorter cycles of the contemporary environment to be effective. Today's threat environment has an increased level of operational uncertainty and demands a broader spectrum of understanding. The enterprise must adapt to these new timelines and present operationally ready forces with greater agility, through more effective training, equipage, application of lessons learned, and current intelligence. In an uncertain environment, DOD must also be prepared to adapt. Hence, realistic exercising and red teaming must become an integral part of preparations.

U.S. forces should expect to operate under degraded conditions from the very start. Degradation may be due to natural phenomena like weather or terrain, self-inflicted conditions such as limited resources or changes in plans, or adversarial conditions such as denial of service. Degradation in execution is an important factor: the ever present cyber threat increases the likelihood of attack during execution, inhibiting access to mission-critical systems and requiring immediate adaptation in the field. The enterprise must have the flexibility to adapt to this new operational environment and its shorter preparation and response timelines. Adapting to compressed timelines provides the added benefit of reducing costs: lengthy preparation cycles create unnecessary cost burdens, which would be eliminated with a more operationally responsive enterprise.

U.S. forces today are facing highly adaptable adversaries, are experiencing degraded capabilities and a blurred definition of readiness, and, as a result, a growing demand for adaptation.

Those involved in combat usually possess a plethora of resources, but time is not one of them; those pursuing serious changes in doctrine, technology, or tactics in the midst of a conflict have only a brief opportunity to adapt. Adding to their difficulties is the fact that as their organization adapts, so too will the enemy.[23]

While a variety of rapid-response mechanisms are now employed to support operations in near-real-time, the planning, requirements, budgeting, acquisition, training, and testing cycles remain firmly based in the rhythms and certainties of the Cold War requirements. These processes remain fully deliberate, constrained by layers upon layers of review and concurrence, fed by additional layers of supporting personnel to create a hierarchy wholly disconnected from the current operational tempo. In parallel, the military industrial base has optimized their business models to operate in this mode, with only isolated examples of responsive, affordable, and innovative behavior. To be able to deliver capabilities to the war fighter in weeks or months (rather than years or decades), radical changes are needed in all processes.

As the above discussion has made clear, the disconnect between operations and enterprise processes is rooted in the Department's Cold War era governance, processes, planning timelines, and associated culture. In a world with an increasing rate of change due to the evolving threat environment, the impact of globalization on technology development and availability, and an increased economic competiveness, inefficiencies emerge from these time-independent system development processes. As much as feasible, the Department must effectively abandon these Cold War era timelines and processes and move the enterprise toward the outcome focus and associated timelines faced by today's operational commanders. In short, it must move to align enterprise functions to an outcome-oriented operational cadence—the topic of the next chapter.

23. Williamson Murray. *Military Adaptation in War,* June 2009, IDA Paper P-4452, p. 8–5.

Chapter 3. Align Enterprise Functions to Support Mission Outcomes

As the previous chapter described, enterprise processes in the Department of Defense are not aligned well to the rapid and changing timeframes of today's operational environment, which, in turn, hinders DOD's ability to adapt. Thus, this study centered its deliberations on how the Department can better align enterprise functions to support mission outcomes—in essence, focusing on how DOD can develop more timely and responsive processes that lead to actions in support of mission success.

The study used two dimensions to frame its recommendations to create a more adaptable and, hence, more effective enterprise: creating shared mission outcomes and enforcing a timely, outcome-oriented response. Shared mission objectives are pursued by focusing war fighter input to achieve desired outcome and responses. Timely and effective responsiveness is produced by coupling real operational time windows to the product output required by the supporting enterprise, specifically aligning enterprise functions and, more importantly, their deliverables to a visibly scheduled, substantive, military objective (*i.e.*, the equivalent of a "launch window" in civilian space applications)—what is being called hereafter an "operational cadence." **The operational cadence is defined to be the time-phased sequence of events that prepares the force to be operationally ready for a particular mission set**. The operational cadence accommodates three overlapping timeframes: rapid, mid-term, and future. In today's complex environment there is no clear delineation between these timeframes and overlap is inevitable.

Rapid Response. Unable to consistently respond to the real-time operational needs of deployed forces in constant engagement with an adversary, the Department has developed, over the past decade, multiple workarounds to drive rapid response to emerging needs. Portions of the DOD enterprise are now in place to respond to urgent operational needs and to provide system upgrades or new systems to address unplanned circumstances; to provide timely changes to tactics, techniques, and procedures (TTPs); and to evolve concepts of operation (CONOPS). While many rapid response efforts (acquisition, TTPs, and CONOPS) have proven successful in supporting current war fighting demands, earlier DSB studies suggest

that systematic improvements are warranted.[24] This study recognizes the importance of rapid response and the need for improvements and makes further recommendations in this area. This study recognizes that the need for such processes to deliver capabilities in near-real-time will be with the Department for the long term.

Mid-term. Since the mid-term provides a tremendous challenge to the Department, this study recognizes the need to better align the DOD enterprise with an operational cadence in order to deliver capabilities supportive of ongoing and/or planned missions. A large portion of the Department's financial resources is devoted to produce capability that could be considered in this mid-term time frame. Therefore, the bulk of the discussion will focus on those portions of the DOD enterprise focused on acquisition, testing, resources, and intelligence, and aligning it to an operational cadence focused on deployment schedules.

Future. The study also recognizes that uncertainty grows as time horizons expand and planning remains important to effectively manage the risk of uncertain futures. However, planning for strategic investment areas, such as long range strike, should incorporate a deliberate hedging strategy, such that "small bets" can be placed on promising technologies that may shape future conditions and prevent committing to solutions that may become obsolete or less relevant before employment.

Each of these areas is discussed in the remainder of this chapter. It is important to note that what is described in this chapter addresses adaptability that goes beyond application to what is traditionally viewed as the Department's acquisition processes. Indeed the study's basic premise is that a clear mission outcome focus tied to operational events will drive needed cultural change across the entire DOD enterprise.

RECOMMENDATION: ALIGN ENTERPRISE FUNCTIONS

Under Secretary of Defense for Acquisition, Technology and Logistics (USD (AT&L)) and Service Acquisition Executives take steps necessary to align DOD enterprise functions to support mission outcomes. In doing so, recognize the needs of both rapid response timelines and hedging to manage the risk of uncertain futures.

24. See *Report of the Defense Science Board Task Force on the Fulfillment of Urgent Operational Needs*, July 2009. http://www.acq.osd.mil/dsb/reports/ADA503382.pdf

Aligning Programs of Record to Unit Deployment

Hundreds of millions of dollars are spent annually on programs of record that have followed the traditional planning and budgeting methodologies. Many of these programs are found to be inadequate in responding to the demands of the contemporary environment because the requirements for these programs are often based on assumptions of the past. Even when deemed successful, these programs deliver capabilities along a timeline defined by the pace of technology development/insertion, the rate of affordability, or the timelines driven by required compliance milestones (*e.g.*, operational testing) and, therefore, are not closely aligned with user need.

Following from the lessons learned by successfully adaptive organizations, systemic adaptability via stronger alignment can be achieved between the operator/customer and the supporting enterprise. This alignment is premised on a shared mission outcome that not only creates clarity among the stakeholders, but also a sense of urgency and commitment, especially over the mid-term. This sense of urgency and outcome focus by operational alignment has multiple beneficial effects—schedules are compressed, costs are lower, and delivery cycles are rapid. Further, the benefit extends beyond the system acquisition community as the supporting Department enterprise functions—training, CONOPS and TTP development, planning and budgeting, and other functions—are incentivized to align to the operator/customer outcome rather than vice versa. Trade space is continuously examined in such an environment and the speed of decision is mission-critical. Failure to deliver a capability to the battlefield or the marketplace increases risk to the organization and is readily visible to all.

The Department's existing mid-term timeline between the near-real-time urgent needs of deployed forces and the longer time horizon of a hedging strategy currently lacks any sense of time urgency and associated focus on mission outcome. Therefore the study identified an opportunity, for those programs where feasible, to align the enterprise with a time dependency process focused on the deployment schedule of the operational forces.

Deployment or exercise schedules represent real world commitments that drive a host of critical activity (manning, training, exercises, etc.) to meet national security objectives. In both the commercial sphere and the military, real world commitments serve as forcing functions that drive the behavior of everyone involved. The Navy/Marine Corps continue to operate on a decades old deployment cycle. The Air

Force implementation of its Air Expeditionary Force is over a decade old. The Iraq and Afghanistan conflicts caused the Army to adopt a deployment-oriented cycle. In today's Army, for example, the operational unit is the brigade and the model used to manage the force and plan unit deployments—including reset, modernization, and training—is termed the Army Force Generation (ARFORGEN) process. Currently ARFORGEN is a two- to three-year cycle for Army units, with a goal to operate on a three- to four-year cycle.

The other Services, as well as the guard and reserve, all work on different operational cadences, as illustrated in Figure 3-1. Coordination within and among these many cadences to meet a national exercise start date is difficult; coordination to meet a joint or coalition offensive operation is far more complex. If coordination is successful, the result can be a well-executed symphony. If a unit fails to meet operational readiness requirements, extreme measures may be undertaken to deploy another operationally ready unit as a stopgap measure, or to adapt the operational plan to the capabilities available. Units may find their deployment location change but their deployment schedule does not slip. Unexpected deployment demands can be met by surging units in the work-up phase. **Adaptation is a necessary process during both preparation and execution phases of the operational cadence.**

Figure 3-2 illustrates a notional operational deployment sequence. At the end of a deployment or major exercise, an operational unit is reset. Initially, the entire unit is broken down—equipment goes to depots and personnel go on leave or to training assignments. Over time, the unit is built up again—existing equipment is repaired and refurbished, lessons learned are applied, new capabilities are acquired, and people and equipment are reintegrated and trained. Having all of this come together to meet a deployment date or an exercise start is the core of the operational cadence.

In contrast, “enterprise” timelines for programs of record (mid-term) and planning and development (long-term) are process-driven with little coordination between the schedule-driven operational cadence. While some parts of the enterprise are more attuned to operations, such as near-term rapid acquisition, TTPs, and CONOPS, barriers make achieving full alignment of the major programs of record very difficult, especially with regard to budget, governance, and cultural impediments.

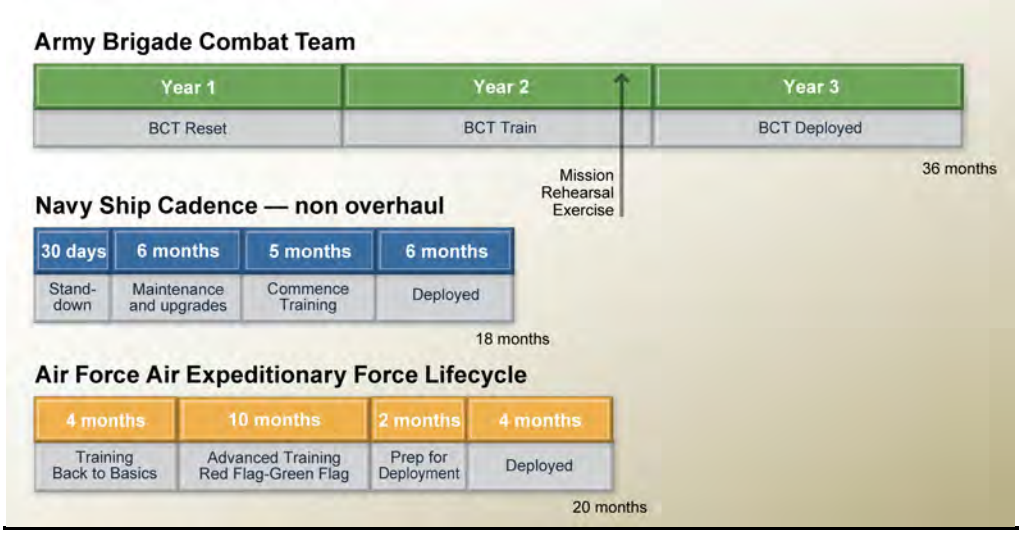

Figure 3-1. Comparison of Operational Cadences for Different Services

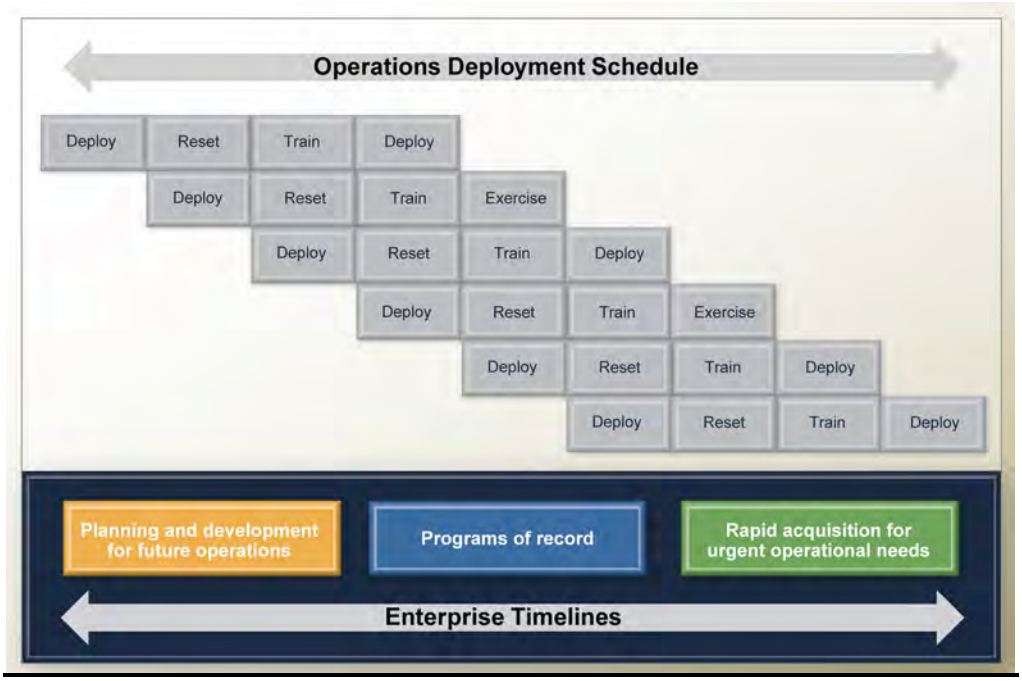

Figure 3-2. Notional Operational Deployment Schedule Disconnected from Enterprise Timelines

Aligning applicable mid-term system development and production processes to a specified operational cadence results in several significant benefits that can incite adaptability in the broader DOD enterprise. When properly aligned, the operational commander plans for and receives new capability during the work-up phase of the deployment cycle, which allows for sufficient integration into the deploying force. When a delivery date is tied to a known mission, operational forces will be better positioned to influence design decisions to support their mission. The feedback loop from operations to enterprise is tightened and valuable capabilities can be delivered in functional blocks.

This approach can have the effect of bringing more of the supporting enterprise into a time-urgent mission focus. For example, the testing community, both operational and developmental, can take operational performance data from the systems returning from a deployment cycle and use that data to refine designs for the next block upgrades and to validate system and subsystem models. Similarly, the training and tactical development communities can take these operational results and feed them back into improved products in those domains.

Using deployment schedules no more than four or five years out, the system developer is able to limit the risk horizon to a manageable scope. As applicable, some programs and capabilities can and should be developed in shorter time frames. Deployment windows are reasonably well known in a four-year time frame and allow for delivery of products, both physical and information-based, tailored to the deployment environment. Subsequent deployments will allow for as-needed block upgrades tailored to different environments and customized as the mission demands. Such an approach supports adaptability in that system development and production processes can more easily respond to changes in adversary capabilities, technological advancement, and other unforeseen circumstances as they arise.

It should be noted that even with major platforms (*e.g.*, ships, planes, and ground vehicles) this approach can occur via time-phased insertion of software upgrades (requiring open architectures, discussed later in this chapter) or via a modular design approach, such as is being employed by the Navy in its Littoral Combat Ship mission modules. The key point is to enforce discipline within the enterprise to tie delivery of capability blocks and their supporting elements (*e.g.*, training and testing) to a real mission and its associated time windows.

On the other end of the spectrum, setbacks in traditional acquisition processes translate directly to delays in fielding for several cycles. Risk and uncertainty in

the development, acquisition, and production processes mean that developing the personnel, facilities, training, and tactics for the new capability does not begin until the first articles are delivered. Instead of immediate deployment, a new capability may have to wait several cycles to allow time for training and operational concept development.

Aligning DOD enterprise processes to the deployment or exercise schedule for an operational unit instills a sense of urgency to field systems more rapidly, with state-of-the-art technology, upgrading over time to incorporate new innovation or changes in operational needs. Current enterprise processes do not function in a way that will support such goals, as has been described previously. They are mired in a compliance-based mindset with endless steps and requirements that must be met before systems can proceed through development and production. Based on such an approach, time is not a critical driver. Instead, DOD needs to adapt best practices—successfully used in industry and in select instances in the Department itself—on an enterprise-wide level that will streamline the current system. Effective practices that the Department should adopt are described in the remainder of this section.

Functional Development Teams

Aligning enterprise processes to a deployment schedule will require an integrated team of stakeholders working toward a shared mission outcome through continuous trade space analysis. An effective functional development team—where members operate as a team rather than simply as representatives of member organizations—is mandated to facilitate this important interaction among stakeholders (Figure 3-3). Within the team, each member's goal is to motivate their home organization to support the outcome most effectively. Without a functional development team to guide critical decisions through short development cycles, the capability will default to the traditional planning model where long deliberate processes are put in place without the mechanisms to intelligently adjust the program schedule and priorities, the technical approaches, and, as needed, the requirements.

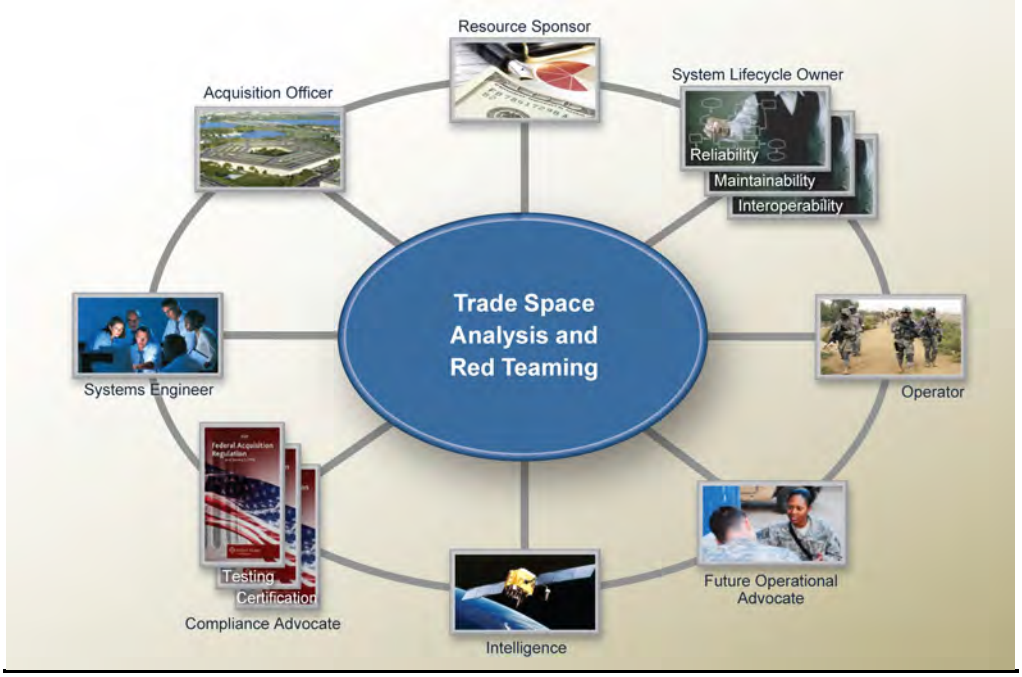

Figure 3-3. Composition of Functional Development Teams

Aligning the team for a successful development outcome. Traditional acquisition progress is made in a step-wise manner. Each function within the acquisition enterprise takes control of the process for a specified period of time before handing it off to the next process. For example, one group might develop a requirements statement before handing off to a budget group, who would then hand off to a systems engineering group, and so on and so on, until the contract is awarded and the entire project is handed off to a design team to await a preliminary design review, then a manufacturing team to await a critical design review, and so on. This method has a number of implications. For example, the requirements and key performance parameters (KPPs) may not be revisited even though the mission scenario feedback evolves over time. The primary drawback to this method is, therefore, the lack of consideration of system trades that could be made throughout the planning, acquisition, deployment, and upgrades of the capability.

Instead, a functional development team should be organized at the inception of major acquisition programs to align the incentives for each of the participating groups to a successful development outcome and the team should remain in contact through the lifecycle of the program. A key attribute of this team is that it functions on a daily basis (if necessary) as an **actual collaborative working team**

with the shared mission outcome—and all members are accountable for the success of the delivery.

A functional development team may be made up of stakeholders or individuals with decision authorities with the following array of responsibilities (Figure 3-3).

- A representative of the operational unit designated to represent the designated mission need and success criteria.
- A representative of a future operational unit that is engaged in drafting requirements to ensure current capabilities align with doctrinal decisions and do not preclude future options.
- A representative of the engineering unit responsible for developing the new capability designated to present the options space for potential solutions.
- A representative of the compliance community to successfully guide the program through compliance with regulations and guidance in areas including test and evaluation, legal, budget, and programming.
- A representative of the intelligence community to provide input on near- and long-term scenarios that provide situational awareness and contextual understanding of the mission environment.
- The acquisition officer to act as the integrator across the complex trade space.
- The system lifecycle owner to represent methods to effectively address the "duties."
- The resource sponsor to secure the proper resources to ensure mission success.

This approach has been used successfully within the DOD, albeit using different terminology and perhaps in a more informal manner, in programs such as the F-117, F-16, and ARCI. One of the primary motivations to use functional development teams is to incorporate adaptability features in systems and families of systems to enable multi-mission capabilities. Furthermore, there is nothing to preclude use of a functional development team to provide guidance at the portfolio level.

Implementation Action: USD (ATL) and Service Acquisition Executives or their designees organize **functional development teams** at the inception of each major acquisition program to align incentives and motivate timely delivery of capability to the war fighter.

Trade Space Analysis

There is no "silver bullet" for achieving an effective and efficient acquisition process, nor is there a straightforward path to determine requirements. It is a complex endeavor, requiring skilled and experienced performers as well as flexibility in a variety of areas. Each of these is an important part of a highly interrelated process, and each is necessary for successful adaptation.

Trade space analysis during program development can be used to assess the relative merit of different system design points; to trade off different systems concepts; and to develop the tactics, techniques, and procedures, and concepts of operations to effectively utilize a new system (Figure 3-4). Additional information is needed to fully understand the trade space. Intelligence provides near- and long-term threat analysis to allow a range of system concepts to be evaluated against a set of scenarios to identify the system design point that provides the widest adaptability. Metrics to compare alternatives and determine superior attributes are needed.

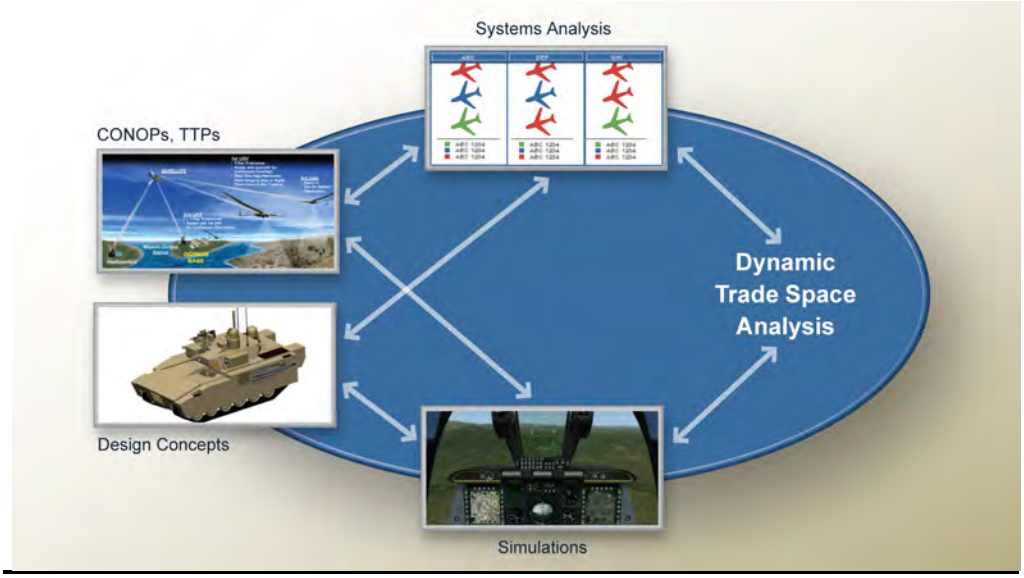

Figure 3-4. Illustrative Trade Space Relationships

Many factors are needed to allow a true trade space to function. These may include:

- **Flexibility and availability of funding** *e.g.*, funding for adequate research and development to make technology available for future block upgrades, or early funding for sustainment planning.

- **Availability of experienced personnel from government and industry** *e.g*, the ability to utilize experienced contractors for field maintenance and modifications. (Chapter 6 of this report addresses means for DOD to better access available human capital.)
- **Options to test, evaluate, and report capabilities and limitations**, rather than merely pass or fail on key performance parameters.
- **Availability of competitive options to provide incentives**, such as the use of open architectures and interfaces, or the ability to use commercial and foreign off-the-shelf products where appropriate.
- **Use of modern tools** to provide links to operators, including real options, simulations, and gaming.

An array of new tools are becoming available for systems analysis, simulation, and gaming, and open architectures that can both enable decision confidence and ensure good decisions are made quickly.

Multi-stage, stochastic, non-linear optimization enables analytic decision analysis under uncertainty over time. This process is currently implemented in mature commercial products for desktop use, and can support portfolio optimization and program decision analysis in DOD. *Real options analysis* allows quantitative valuation of adaptability in system engineering and design. This approach efficiently allocates resources to manage risk in development and operations. While in limited use within DOD, these new optimization techniques are already benefitting industry:

- Telecommunications: 75 percent reduction in lost calls[25]
- Electricity production: 11 percent reduction in grid connection cost[26]
- Insurance: $40 million savings per year in a single, mid-size company[27]
- Manufacturing: BASF Corporation cut distribution centers by 80 percent and saved $10 million per year[28]
- Transportation: CSX railways saved $2 billion in operations costs and equipment avoidance[29]

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25. Suvrajeet Sen, Robert D. Doverspike, and Steve Cosares. "Network Planning with Random Demand," *Telecommunication Systems*, 3:1, 1994, pp. 11–30.
26. "Stochastic Optimization of Wind Turbine Power Factor Using Stochastic Model of Wind Power," *IEEE Transactions on Sustainable Energy*, 1:1, April 2010, pp. 19–29.
27. "The Russell-Yasuda Kasai Model: An Asset/Liability Model for a Japanese Insurance Company Using Multistage Stochastic Programming," *Interfaces*, 24:1, January-February 1994, pp. 29–49.
28. I. Grossmann. "Enterprise-wide Optimization: A New Frontier in Process Systems Engineering," *Journal of American Institute of Chemical Engineering*, 51:7, July 2005, pp. 1846–1857.
29. Michael F. Gorman, Sharma Acharya, and David Sellers. "CSX Railways Uses OR To Cash In on Optimized Equipment Distribution," *Interfaces*, 40:1, January-February 2010, pp. 5–16.

Physics-based modeling, simulations, and gaming can be used to rapidly create relevant environments to explore both existing and new technology concepts and concepts of operations. Advances in simulation capability allow complex missions to be easily visualized by war fighters as well as the rest of the functional development team. Alternate mission scenarios can be reviewed and the merits of alternate equipment and various concepts of operations can be determined including by man-in-the-loop simulations.[30]

Simulating the operational scenario early in development. When used proactively, these methods will ultimately reduce product development time. Current capabilities are emerging from a mash-up of mission rehearsal tools and the computer-aided design (CAD) and physics-based tools used to design and model equipment and systems. The CAD and physics-based modeling tools allow designs of new systems to be modeled, and look-up tables can be created for use in the mission rehearsal tools. The mission rehearsal tools, based on state-of-the-art gaming technology, allow personnel to rapidly learn to operate the system and to customize new missions.

The mission rehearsal can then be carried out with any combination of human and artificial-intelligence participants. Effective simulation and gaming capabilities will allow for man-in-the-loop, artificial intelligence red and blue team members, and a large number of neutrals (that may be either human or artificial-intelligence) engaged in the operational scenario. The use of these techniques early in a development program will reveal weaknesses and likely counterstrategies, allowing evaluation and system changes at a time they can be made quickly and at low cost. The input from a wide spectrum of users suggests that these techniques are critical during the first steps in the development of a new capability. Understanding the full range of how a capability may be used or countered will be greatly improved with greater participation in the early stages.

Implementation Action: USD (ATL) and Service Acquisition Executives require use of **trade space analysis** including simulations with operator input for all major system acquisitions before critical milestone decisions. Additional tools, such as mission rehearsal gaming, may also help clarify true system needs and paths to adaptability.

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30. A significant number of programs and studies have made recommendations to continue to develop and expand this capability. The USAF Scientific Advisory Board report on "Building the Joint Battlespace Infosphere," SAB-TR-99-02, discussed the combination of virtual and physical systems permitting mission rehearsals and a study by the Office of the Director, Defense Research and Engineering, *Rapid Capability Fielding Toolbox Study*, stated that virtual environment tools can be used to rapidly elucidate the benefits of alternative approaches.

Open Architecture

Systems are much more adaptable to changing conditions if they are initially designed (or for legacy systems, their upgrades are designed) with modular concepts, and with well-designed standards and open interfaces and protocols. Modern defense systems are typically deployed for very long lives, and must adapt over time to changing threats and new requirements. In the dynamic environment that has evolved since 9/11, the threats and requirements that new systems must address in ten to twenty years are not only difficult to predict, but in fact are unpredictable. Therefore, DOD must design with open architectures and build systems in ways that allow them to adapt over time to the changing environments and new threats in which they must operate.

During the Cold War, military investments often drove technologies and were later adapted to the commercial market. Over the past twenty years, this phenomenon has flipped, and investments in commercial technology have often enabled military systems—particularly in the areas of computer processing (including field-programmable gate arrays), storage, and communications.

Faster upgrades, better information-sharing. Planning systems with modular, open architectures and using commercial standards whenever possible allows these systems to more readily incorporate commercial investments, while delivering more capability to the war fighter faster than ever before. Standard protocols and interfaces allow such systems to upgrade "their brain" (processors and storage) without requiring the time and expense of redesigning other major functions of the system. An additional requirement of modern warfare, as well as of the fight against terrorism, is the ability to communicate between all echelons within the DOD, and between other U.S. agencies and coalition entities. Thus, interface definitions should include standards to allow desired data sharing. Communication standards are needed not only for voice, but also for sensor and situational data. The responsible authority for execution is the USD (AT&L).

Planned and rapid upgrades are enabled through published, non-proprietary interfaces using commercial and international standards, open data models, separated functionality, and remote functional upgrades, where possible. Much has been written on the need for and success of open architecture systems. DOD has begun to procure more of their systems with open architecture requirements. However, systems are still procured and upgraded within closed (proprietary) architectures that significantly reduce the ability to upgrade and maintain the system over its lifecycle. (See Appendix C for further discussion of open architecture systems.)

The definition of open architecture must be clearly defined for successful use of this tool in system development. Key attributes for open architecture are as follows:

- Use published, non-proprietary interfaces supported by commercial and international standards when possible.
- Provide data model to define data exchange between segments of the open architecture system.
- Use interface definitions to separate hardware and software functions.
- Separate functions into definable subsystems.
- Specify software to allow remote upgrades whenever feasible.
- Ensure government ownership of the data rights at the interfaces.

It is important to recognize that the above list must be comprehensive and complete and truly enforced by the acquisition program management. For both open systems and COTS, it may appear to be to the contractor's benefit to "stretch or spin" that a design or system appears (superficially) to meet these criteria (for example, to retain a competitive advantage for follow-on work) when in substance these criteria are not met. Enforcing these attributes with technical substance requires a smart buyer with subject matter expertise on the government acquisition team. The Navy's ARCI program, discussed in Chapter 1, is an excellent example of a successful open system architecture using commercial standards.

Improved performance and dramatically reduced cost. The basic premise of open architecture exemplified by ARCI is that by allowing the system to be quickly and affordably updated, the system can take full advantage of Moore's Law and the investments occurring in the commercial marketplace. In contrast, proprietary, closed systems will age quickly even if they are designed with modern processors, which makes updating the system prohibitive in terms of cost and schedule. The complicated software linkages between modules increases the complexity of designing the system to a point where closed systems processors are often obsolete before the systems reach initial operational capability (IOC). Open architecture has the important benefit of enabling competition throughout the life cycle of the program with potentially lower costs of future upgrades and enhancements.

Implementation Action: USD (AT&L) direct that requirements processes for new systems and major upgrades provide for **open, modular architectures**, flexible design concepts, and interoperability.

Block Development and Fielding

A primary factor in any trade space analysis is the breadth and depth of the planned deployment. For example, whether a new helmet design is needed for every soldier or only for soldiers in certain units can dramatically affect production timelines. Producing fewer units but producing them more often—and perhaps with upgraded capabilities in future blocks—is a powerful tool in the trade space. The benefits of aligning block deliveries, as feasible, to specific deployment schedules were discussed earlier in this chapter. What follows is a more detailed description of block development and fielding that, itself, is critical to an adaptive military.

Building blocks, not one-size-fits-all. Much of the current force structure has a one-size-fits-all model in preparing for conflict with a near-peer competitor. But the forecasted need to increase support for tactical and low-end conflicts suggests a "block" approach for building, equipping, training, deploying, and supporting the force. By giving combatant commanders the ability to build force structures with varying size, lethality, technical capability, and training, the fighting force can be tailored to suit mission needs in a rapid fashion. These tailored forces will be better suited to deal with the spectrum of conflict the United States is expected to encounter in the coming decade. In order to enhance the potential for more effective mixed-force structures, future acquisition programs should plan on a "block build" strategy that permits more affordable acquisition in blocks and earlier initial operational capability for the first few blocks.

A key factor in meeting an IOC on time is the option to trade guaranteed future capabilities through pre-planned block buys. Schedule is a first priority, and additional build cycles are designed to support operator needs now and in the future. When sufficient adaptability is designed upfront into a program, the block build approach supports unknown future needs. If the environment undergoes significant change, then new capability can be inserted as part of a block upgrade, rather than by starting a new program. Time-phasing capability is much more cost effective and timely than trying to build a system that encompasses every conceivable threat over the next 10 to 20 years. Open architectures and implementation of published standards facilitates competition across blocks.

Lower risk and more frequent fielding. Designing systems with open architectures and standard interfaces makes it much easier to upgrade the system in the future. Figure 3-6 illustrates how designing the architecture and planning the program budget for pre-planned block upgrades will ensure the system is adaptable and flexible to meet continually changing needs as the mission evolves over time.

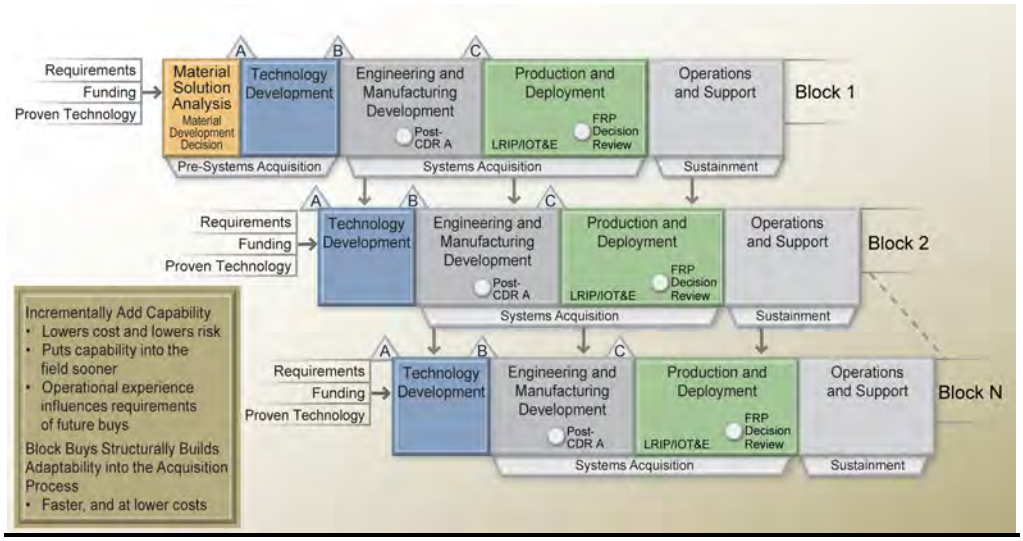

Figure 3-6. Designing for Pre-Planned Block Upgrades

Implementing a block-buy strategy enables lower risk, lower cost, faster deployment, and addition of valuable mission performance. Systems would benefit from pre-planning continuous production, in smaller quantities, defining block upgrade cycles, and maintaining core development teams. Block buys and spiral development are proven techniques for reducing acquisition risk and, therefore, program costs in major acquisitions. By starting a system with an 80 percent solution built from existing technologies (Block 1), useful capability is delivered to the field faster, and at lower risk and cost than a traditional "waterfall development" meeting full mission needs. The fielded capability provides an opportunity for earlier operational feedback that will influence future block builds and increase suitability.

Cost and execution are incentivized by ongoing competition at the prime and subcontractor levels. By maintaining a lower risk profile for the development team, costs are reduced, delivering capability to the user more affordably. The program stays relevant through more frequent fielding and operator feedback, and matures as future blocks are developed.

Planning must include adaptability as a specific requirement metric, with built-in flexibility for future modifications to increase system adaptability. To better understand the utility of future modifications, exercises should be carried to the stress point. These exercises should use functional prototypes and be used as data sources to validate models and the underlying parameters (*e.g.*, physics) of

full trade space analysis. They should be modeled on live-fire exercises, and should include after-action analysis.

Such a strategy allows for orderly, continuous upgrades, minimum change during any one cycle, and surge capacity. Proper contract strategies would ensure competition (often at the subsystem level) and reduced unit costs, while adding flexibility.

Revisiting requirements to validate needs. To be successful in implementing a block upgrade strategy, it is also necessary to implement an approach to managing requirements uncertainty. Developing to a near-term deployment schedule should and must drive requirements that are constrained to the expected environment. Absent such a constraint, the system is likely to revert to the current unconstrained and unrealistic requirements process and all the problems that result therein. Revisiting requirements throughout the system lifecycle is an important method of regularly reviewing and validating system needs. Unnecessary requirements should be eliminated when operational experience indicates they are no longer valid.

For example, Army leadership described to this study a program manager struggling to solve a vehicle stability problem due to up-armoring. The program manager was constrained from implementing the simple and cost-effective solution of increasing the wheel base by a KPP that required the vehicle to fit in a C-130. However, in over eight years of operations, the vehicle had never been transported via a C-130. When Army leadership waived the KPP, the program manager was able to easily and cheaply solve the stability problem. Requirements uncertainty should be incorporated into system design, and requirements should be treated as stochastic constraints/design parameters during design. Importantly, requirements must be articulated with sufficient flexibility to be consistent with an 80 percent solution, especially in Block 1. New or postponed requirements should be planned for future blocks.

Experience informs future blocks. Many programs with planned block buys in the past have suffered from the buyers inserting 100 percent of their desired requirements in the first block—essentially killing the concept of reducing risk and speeding capability to the war fighter. Most of these programs suffered major cost and schedule overruns driven by the risky technologies being inserted into the initial buy. By managing the requirements consistent with a desire for an 80 percent initial solution, there is less pressure to insert risky technologies into the early buys, allowing the technology to mature for insertion into a later block. With this approach, capability gets to the field sooner, and experience gained by the users offers valuable feedback by which to inform later block requirements.

Evaluating capabilities and limitations. Equally important is to align the test community with goals of the functional development team. Integrated test strategies, consistent with 80 percent solutions and block buys, are needed. This approach means a shift in test criteria from "pass-fail" to reporting the capabilities and limitations of a system, similar to the current approach used for Army rapid acquisition programs. Evaluating capabilities and limitations allows a functional development team to manage, rather than avoid, risk by making appropriate trades to optimize support for current missions.

To facilitate block upgrades, the Department should stick to maintaining continuous competition and take full advantage of commercial or foreign military sources (factoring for security and vulnerability). Looking holistically at all sources when acquiring systems and subsystems gives the Department options for consideration that it wouldn't have otherwise. The Mine Resistant Ambush Protected (MRAP) vehicles program is an example of using designs and components from around the world to fulfill an urgent need.

It is noted that traditionally mixed force concepts are avoided because of added complications to such areas as training and logistics. To some extent that will always be true, but increasingly the benefits far outweigh these complications—the significant operational benefit of having systems much sooner (saving money) and a diversity of force better suited and more easily adapted to different missions and conflict types. Further, training and logistics with mixed force concepts can be enabled with information technology capabilities—*e.g.*, on-line training manuals and operational processes kept current by a menu of training modules to support specific blocks and deployments. For example, the Stryker vehicle's network capability enables the next deployer to prepare for deployment using the in-theater real-time data collected during operational missions by previously deployed units.

Implementation Action: Enable rapid force adaptation through a **mixed-force structure of equipment and personnel**:

- Combatant commanders and Service chiefs recast use of existing systems to build mixed-force fighting capabilities for near-term contingencies.
- Joint Requirements Oversight Council rebalance materiel procurement quantities to enhance future mixed-force structure to meet mid-term needs.
- USD (AT&L) identify research and development most critical to further enhancing a mixed-force for tactical contingencies and provide effective logistics.

USD (AT&L) and Service Acquisition Executives implement a **block upgrade strategy** (pre-planned and unplanned) to continuously improve systems. Align programs, contracts, and budgets to support this approach.

Contractor Flexibility

Current contracting processes are a barrier to developing rapid, effective and adaptive systems to meet combatant commander needs. Contracting processes do not support rapid response and severely limit any ability to trade requirements and schedule once a procurement action is initiated. Furthermore, while contractors are critical to acquisition, fielding, and upgrading of adaptive systems, this is not recognized in the incentive structure of the contracts.

Making changes easier and building in incentives. In order for contractors to contribute meaningfully within the operational tempo described previously, current contracting processes and procedures must be more streamlined and tailored to support adaptability. Current contracting processes make it difficult and very expensive to change or update an open contract to respond to the contemporary environment. Yet, the dynamics of today's operational environment may necessitate the elimination of constraining requirements or the inclusion of new capabilities at any time during program development. Although exceptions exist, even when an urgent need is identified, the Department uses the same contracting process that is followed for traditional system acquisitions. In instances where an effort is made to develop adaptable, responsive systems, the contract process is handled outside of normal channels.

It is also important to acknowledge that contractors play a pivotal role in the Department's ability to acquire, field, upgrade, or modify systems. Restrictions on "color of money" and distinctions of whether an activity is a development effort or for sustainment make adapting fielded systems difficult. Contractors are often not contractually committed to life cycle system support due to their declining role after deployment. As a result, there are few incentives for contractors to design systems to be adaptable.

Contracting processes and requirements have to be crafted to support acquiring and fielding adaptable systems. Contracts need to be executed with incentives that promote the smart and cost-effective use of contractors throughout a program's life cycle to enable rapid response and adaptability. In addition, contractors can be used to motivate retention of critical skills and develop system designs that are easily modified. Contract vehicles should emphasize the need for contractor support (as required) for

field upgrades, deployments, exercises, and training. Contractors can also be utilized to assist forward-deployed engineering teams (discussed in a later section of this chapter) to capture operator "lessons learned" that can be reflected in pre-planned product improvements and block upgrades, as described previously.

Implementation Action: USD (AT&L) establish **flexible contracting procedures** designed to enable smart use of contractors over the life cycle of a program:

- Enable tailored contracting processes to support rapid minor systems upgrades/ modifications.
- Encourage competition at the subsystem level through open system architectures.
- Enable retention of critical skills to support orderly, continuous upgrades and surge capacity.

USD (AT&L) **acknowledge the key role of contractors** in acquiring, fielding, and upgrading systems by putting in place incentives that motivate: on-time performance, enhanced field support for upgrades and deployments, design to support incorporation of user/operator lessons learned, participation in exercises and training.

Provide Support for Program Managers

Experienced, knowledgeable program managers are critical to the Department's ability to align programs to an operational cadence. The Department has justifiably emphasized training for selected military officers and civilian staff in acquisition fundamentals and has provided graduate training in areas ranging from political science to various technical fields. However, high-technology defense acquisitions demand deep knowledge and practical experience in multiple engineering and business fields. Normally, rotational military officers and civilian staff simply do not have this knowledge and experience, nor are they in place long enough to acquire it.

Learning by managing programs. The rate of change and increasing specialization of technology and commercial innovation demands a competent cadre of government program managers. These individuals develop most effectively by performing and learning while managing actual programs or program components. However, building this talent has been a challenge for the Department. For example, whatever technical and related program management training officers receive may lie fallow for years as they rotate among operational, staff, and unrelated acquisition

assignments. Similarly, civilian staff who have substantial technical education usually receive it early in their careers and often do not actually employ and deepen this knowledge in their day-to-day duties. Unless civilians enter federal service in the middle of their careers, they may never have professionally designed or built a major system. Experience in program management is gained by successfully managing increasingly complex programs.

On-demand access to experts. The DSB recommends that, where possible, the USD (AT&L) implement a strategy wherein program management offices (PMOs) have on-demand access to up-to-date management and technical experts as part of a formal mentoring process. Such experts would be experienced in program management and act as consultants and "red team" members, proving a resource pool for program managers. These experts would work on the "government's side of the table" and be excluded from working on the "contractor side" of that program for an appropriate period of time to avoid potential conflicts of interest.

Training in state-of-the-art approaches. Finally, DOD should strengthen the curricula and faculty of the Defense Acquisition University (DAU) and the Service colleges by enhancing courses in technologies and commercial development practices in areas pertinent to major DOD acquisitions. Current staffing does not reflect strong experience in commercial state-of-the-art product development approaches or evolving best practices. An added focus would be to provide templates and sample documents (including case studies) to program managers at program start up (that come from successful rapid acquisition programs). Similar training could be made mandatory for DOD civilians and political appointees as part of their assumption of duties. (Training for adaptability and accessing skilled personnel is discussed further in Chapter 6.)

Social networking for program managers. To encourage the culture to move from a risk-averse, compliance-driven orientation to one focused on achieving affordable, timely results, DAU should modify relevant curricula to describe the waiver approval process and make it clear to program managers in training that appropriate waivers are acceptable and encouraged. The use of social networking tools has significant potential to share experiences with streamlining processes across the defense enterprise. Following the example of such initiatives as companycommander.com, DAU should foster the creation of social networks for sharing information on the waiver process and on flexible and creative approaches for working within and around the system to avoid the need for a waiver across programs.

Implementation Actions: USD (AT&L) re-emphasize the need for **strong program managers** and take steps to strengthen capabilities:

- Implement a strategy wherein program management offices have on-demand access to up-to-date management and technical experts as part of a formal mentoring process.
- Direct DAU and the Service colleges to add faculty with experience in commercial best practices and supplement current faculty with advisors who have experience outside DOD processes.
- Direct DAU and the Service colleges to strengthen the curricula by enhancing courses in technologies and commercial development practices in areas pertinent to major DOD acquisitions.

DAU foster the creation of social networks for sharing information on program management experiences and process streamlining.

As described in the introduction to this chapter, the proposal to align enterprise functions to an operational cadence will still require rapidly acquiring capability through acquisition, procurement, and development of TTPs and CONOPS to account for the surprises encountered in real world operations. However, a system aligned with an operational cadence will better connect the acquisition community to the contemporary operational environment and thus be less reliant on reactionary processes and systems. Long-term traditional planning will also benefit from tighter feedback loops in a block approach to introducing new or improved capabilities. Both rapid and long-term planning will remain relevant and can benefit as well from improvements to current processes, as the remaining two sections of this chapter will describe.

Rapid Response

Aligning the enterprise to an operational cadence will, if done effectively, decrease the need for rapid acquisition by making the enterprise more responsive to the operator. Even so, it will not be possible to anticipate every need and prepare for all conditions. In an uncertain, complex, rapidly changing environment, the Department must be prepared to respond effectively to whatever circumstances arise. Rapid adaptability in the field allows existing equipment inventory to move quicker to the fight. In turn, more effective war fighting, with better capabilities,

could end conflicts more quickly. Such adaptability, broadly defined, can also serve as an effective deterrent and an important tool to affect the behavior of potential and current adversaries.

The challenge remains to overcome the barriers to rapid response that are presented by the many institutional processes that require extensive time, paperwork, and approvals. These processes are intended solely to minimize risk, and therefore do not provide the flexibility required for rapid action. These processes encompass requirements generation, budgeting, acquisition, test and evaluation, support, education, and others.

Rapid Changes to TTPs and CONOPS

In the ongoing conflicts against insurgency and terrorism in Iraq and Afghanistan, U.S. forces encounter an agile enemy adapting quickly in the tactical arena. Changes in the way U.S. forces fight and are supported—in TTPs and CONOPS—offer one of the fastest responses to an adaptable enemy. In fact, numerous examples drawn from experiences in the field in recent years illustrate how agile and creative U.S. forces are at the lowest tactical level.

In many instances, the study heard examples in which supporting organizations (*e.g.*, training and intelligence) embedded members of their organizations with theater-based troops to optimize the flow of information between the operational forces and the supporting organizations. Embedding eliminated middle layers capable of distorting and/or delaying the most relevant information. In the case of embedded intelligence capability, the synergy created by the close proximity significantly enhanced the overall capability well beyond the shortened communication cycle. Unfortunately this valuable practice appears focused only on the current operational forces. The study heard of at least one instance in which the training organization could not support operational forces training for peer-on-peer engagements, which resulted in the first few days of the training session spent learning old lessons.

Higher up the chain of command, however, communication and response time slows and becomes less efficient. A significant lag often exists between the request and the response. These responses may be changes in TTPs and CONOPS, or access to additional equipment or control of shared C4ISR (command, control, communication and computers, and intelligence, surveillance, and reconnaissance) assets.

Recognizing needs and implementing changes in the field. It is critical to facilitate proactive and frequent questioning of relevant TTPs and CONOPS.

Experience in Iraq and Afghanistan has shown that the overwhelming majority of urgent needs from field commanders are requests for equipment they do not control. For example, operator control of ISR resources has been a concern to ensure efficient and rapid response to critical changes in the operational environment.

Training for changes in TTPs and CONOPS is important, but not adequate for field adaptability. Training must be coupled with an understanding of how to recognize the need for change and the operational boundaries ("rules of engagement") acceptable for modifying approaches in the field. To facilitate this adaptation, expert teams, with broad and relevant education, should be assigned to training centers to teach units how to recognize and implement change, and are ready to deploy to operational theaters.

Implementation Action: The combatant commands, working with the Joint Staff, develop a quicker and more effective process to **rapidly change TTPs and CONOPS** across units and Services. Such a process will require rapid and distributed collaboration among users in the field with the help of experienced operators and system developers.

More Effective Rapid Acquisition

Each military service and the Office of the Secretary of Defense (OSD) have established rapid acquisition activities. In fact, more than twenty such organizations exist in the Department today. These activities operate outside of the 5000 series acquisition process and require waivers to many rules and practices.

While many urgent needs have been met through the efforts of these activities, there are problematic elements of them as well. Many are overstaffed and, in many cases, without sufficient domain, technical, or acquisition experience. In general, these organizations stop exhibiting rapid characteristics when they exceed more than 50 individuals who have expertise in both rapid response and in the subject area to which they are rapidly responding. (The number of personnel assigned to the Joint Improvised Explosive Device Defeat Organization [JIEDDO], for example, has grown to more than 3,100 people.) Little focus is spent on differentiating rapid programs for long-term retention (*i.e.*, transition to a program of record and subsequent attention to sustainment and training) and those programs that are disposable and should not be forced into the normal program of record track. They also require rapidly available funds, which until now have come largely from

supplemental funding to the defense budget. Further, there are no plans to institutionalize or sunset these many rapid acquisition activities.

A schedule-driven process led by a small, experienced team. The key to rapidly responding to unexpected combatant commander needs is the option, in selective situations, of employing a parallel, rapid acquisition process, in contrast to the "deliberative" process. This process must be "schedule-driven"; have available authority and funding; be staffed with a small group of experienced people; and have full, senior-level support for obtaining necessary waivers. Once the urgent need has been satisfied, the effort (if the threat continues) should become a "program of record" or, if the need is satisfied, the effort should be "sunset."

Implementation Action: For **rapid acquisition programs**, each Service transition to a single organization established similarly to the Air Force "Big Safari" program, with a small, very capable, and experienced staff of 20 to 50 people.

Each organization should have access to adequate funding—estimated at $25 million in research and development and $100 million in procurement—with contracting authority for rapid response. Spiral development, as described previously in this chapter, should be used to get the 80 percent solution rapidly to the field. These organizations should operate with adequate transparency and report to the Office of the Secretary of Defense and the Joint Staff.

Forward-Deployed Engineering Teams

To ensure implementation of appropriate rapid responses—for equipment, TTPs, or CONOPS—the DSB proposes the creation of small, agile, forward-deployed teams. These teams would be deployed in order to gain full understanding of the urgent need and to facilitate the response. Teams would comprise experts appropriate to the equipment or tactics being modified, and contain all necessary engineering, acquisition, and operator disciplines to provide quick-turn adaptive solutions to war fighter needs. Disciplines may include systems engineering, concept of operations development, information technology (sensors, computers, and networks), image processing, hardware and software design and modifications, rapid prototyping, and familiarity with electronics and hardware manufacturing. Smaller teams with fewer, but more experienced people will produce faster and better results, meaning that some teams may be specialized rather than cover all disciplines.

The teams could be semi-permanent or *ad hoc*, as appropriate, and would deploy with the operational forces in both training and actual combat. They would be funded and supported by materiel commanders, supported by program managers, and report directly to and under the control of operational commanders at the 2-star level or above. The teams would deploy in self-contained transportable facilities to allow rapid relocation. The field support teams could include a mix of military, government, and contractor personnel. In addition to rapidly implementing needed system modifications, the teams would be responsible to traditional support commands for configuration control. The forward-deployed engineering teams would also assist as an interface between war fighters, requirements developers, and acquisition organizations to define system block changes and the requirements of future systems.

Implementation Action: USD (AT&L), working with the Service Acquisition Executives, create **forward-deployed engineering teams,** serving at the direction of the combatant commander, to efficiently triage operational needs, translate them to actions, and effect fulfillment in days or weeks instead of months or years.

Field Modifications

As part of the materiel commands, forward-deployed engineering teams would also be useful for field modifications. This should be done with support from program managers and Service Acquisition Executives to solve enterprise hurdles. Much of the equipment now deployed with U.S. military forces will remain in use for many years. Most deployed systems are improved over time for a variety of reasons. In times of peace, these improvements generally are implemented based on lessons learned from exercises and the discovery of new technology. During combat, the need for changes and improvements arises when the enemy introduces new tactics or technology. Current procedures for modifying fielded equipment to adapt to these changing conditions are cumbersome and vary by equipment type.

Field commanders generally do not have the capability or funding to rapidly modify equipment being used by their forces. As a result, they depend on supporting commands that are in distant locations and operate in the "deliberate" acquisition process designed for peace-time acquisitions, or the joint urgent operational need (JUON) and urgent operational need (UON) processes for urgent modifications. Both of these tracks take time and often leave the operational commanders without the needed capability to succeed for lengthy intervals.

Barriers to rapid adaptation also include lack of funding, contract support, and separation of technical expertise from field support.

This problem can be partially solved by creating a capability for operational commanders to modify software and hardware in the field, using resources under their command. Such a capability will require funding, flexible contracting procedures, facilities, and technical support.

The summer study observed two positive examples of field modifications that should be a model for others: the Army's Mobile Parts Hospital that has operated in theatre over the past decade and the more recent development by U.S. Special Operations Command of the Mobile Technical Complex. In both cases fielded equipment and systems are able to be repaired, tailored, and modified for current mission needs while in theatre.

Implementation Action: USD (AT&L), working with the Service Acquisition Executives, quickly develop a robust **in-field system modification capability** for each Service. This capability will primarily address software upgrades, but may also include minor hardware upgrades.

Hedging and Shaping Strategies to Manage Risk in an Uncertain World

As the opening of this chapter explained, more adaptable processes allow existing equipment inventory to move more quickly to the fight. At the same time, some investment should maintain a focus on the longer term to keep options open for uncertain futures and to take steps to shape the future to U.S. advantage wherever possible. Thus hedging and shaping strategies are required to manage risk in a world where it is not possible to invest for all scenarios or to defend against all our nation's vulnerabilities. **Risk management is an essential element of enterprise leadership.** Plans, as devised, rarely survive the first contact with the adversary.

The Department can benefit from developing strategic investments that will hedge undesirable adversary force developments and steer them to adopt more favorable force postures. An example would be investing in an offensive capability that would force an adversary to rethink, restructure, and reinvest in new defensive systems in order to counter the new U.S. capability. Shaping investments could also be

undertaken as part of a deception campaign—*i.e.,* the capability has no intention of being fully developed but instead *appears so.* A peer country, focused on defense, is better than one focused on offense and force projection. Full spectrum operations between peers in the future are expected to include rapidly-evolving combinations of simultaneous pressure from multiple points, across the full warfare spectrum. Risk management offers the means by which the DOD enterprise can best plan to mitigate against the adaptability challenge of the future for the combatant commanders and the troops under their command. Risk management approaches include: **shaping, hedging through anticipation,** and **red/blue teaming.**

The uncertainty associated with the conduct of future combat increases the importance of utilizing anticipation in order to get ahead of future issues. Anticipation increases the planning horizon so that potential blue force and red force vulnerabilities can be identified. It also creates the opportunity for mitigating these vulnerabilities. Anticipation of alternative scenarios, informed by red/blue teaming on TTPs and CONOPS, creates the foundation on which hedging strategies can be built.

Embracing both faces of risk. In recent years the Department has begun to shift from pursuing *individual acquisition programs* that produce exquisite capabilities at high cost and long lead time, to pursuing *portfolios of capabilities* organized around missions and rebalanced toward "good-enough" capabilities acquired at lower cost and time-to-field. Senior managers have been urged to "accept risk" in making trade-offs among competing security demands, and responding with alacrity to the needs of current operations. However, this shift is complicated by risk-aversion: the pervasive view that uncertainty and risk are "bad"—something to be avoided, minimized, endured, and retired; and a "central planning and control" culture emphasizing development and execution of fixed program plans. Both of these characteristics are corrosive to the Department's ability to adapt to changing conditions.

Risk is a two-sided coin. There are certainly down-side risks where potential consequences are negative, and sometimes unacceptable. However, there are also up-side uncertainties that offer potential opportunities for U.S. capability, and which offer the United States the opportunity to impose complexity and cost on its adversaries. As part of its shift to adaptive portfolio management and system acquisition, the Department must embrace both faces of risk, and most importantly, move from accepting risk to actively managing risk.

Hedging: proactive risk management. The fundamental difference between passively accepting risk versus actively managing risk is in proactively shaping and preparing for uncertain conditions. Proactive measures taken in advance of uncertain events are termed *hedges*. The courses of action prepared for in anticipation of potential future events are termed *recourse actions*. In managing mission portfolios and defense acquisitions, an effective strategy will be composed of a projected critical development path, hedges, and flexibly planned recourse actions—all designed to exploit up-side opportunities, reduce the likelihood and impact of down-side uncertainties, and inflict maximum uncertainty and cost on the adversary.

Another hallmark of active risk management is the use of hedges to **defer final commitment in design and budgeting until needed to hit a desired fielding date**. Deferring commitment may seem paradoxical given the Department's increasing emphasis on responding faster to urgent operational needs and changing conditions. The Department's central-planning and oversight processes have established "approved" planning scenarios, operating concepts and conditions, and threats as the basis for requirements. Requirements are formally established through a lengthy process, that includes Service, joint, and OSD approval channels. Once approved, such requirements anchor system specifications and point-designs early in the acquisition process.

These designs and specifications are embedded in defense contracts, and program managers and service acquisition executives are urged to minimize subsequent changes (*e.g.*, requirements "churn"). Such requirements and designs frequently fall victim to changing conditions, budgets, and operator needs as programs are executed. Often the Department discovers that the "approved" basis for requirements is divorced from reality, and setting system requirements in the absence of technical design, cost, and schedule trades was folly. Embedding the resulting specifications and designs into long-term, single-vendor contracts makes later course corrections difficult and costly.

The summer study proposes modifying this overall approach by tying acquisitions to an operational cadence; bringing the operators, engineers, budgeters, and acquirers into an integrated functional development team; aiming initially to rapidly field 60–80 percent solutions while subsequently enhancing capability via block-upgrades; and maintaining open competition and competitive sources of supply—all described in previous sections of this chapter. **Developing acquisition strategies that feature hedges and recourse actions is an additional critical element of this revised approach**.

Such hedges should be constructed to allow mission portfolio managers, program managers, and service acquisition executives to defer design decisions and related resource commitments until later in the acquisition process, when many key uncertainties are resolved. Hedge investments should be used not only to prepare for recourse actions, but also to "buy information" and "buy flexibility" in design decisions and suppliers over the course of the acquisition. Rather than guessing at "approved" conditions and operator needs years in advance, portfolio and acquisition strategies should employ a block-oriented development approach, backed by multiple hedges to enable adaptive long-term development—that is, actively manage risk via hedges: do not accept it, avoid it, or assume it away.

Analysis tools to support hedging. In the past, the main problem with attempting to use hedges in this manner has been the inability to compute appropriate levels of investment for both the near-term development path and hedges. Traditionally, a classic program analysis of alternatives (AoA) involves cost versus benefit or cost versus mission-effectiveness analysis. While sometimes complicated, such AoAs involve a single decision stage among definite alternatives to implement a single course of action against a single set of circumstances—such as "decide now between X, Y, or Z."

To construct a strategy and allocate resources using hedges is more complicated. It involves two- or multi-stage decisions: decide X-Y now, then decide A-B-C later, migrate the path to adopt A-B-C, establish D-E as a hedge path, and so on. Furthermore, resource allocation must accommodate the reality that many things are uncertain—costs, future conditions, performance levels, and benefits, for example. Such problems have traditionally been in the "too hard" category: literally "N-P hard" optimization.[31]

However, recent innovations now make such planning feasible. New methods and tools that facilitate trade space analysis, as described previously in this chapter, also apply to analysis in support of hedging investments. Advances in operations research have created optimization methods that dramatically reduce the computational complexity involved in multi-stage problems featuring uncertainty. These methods include interior-point algorithms that more rapidly converge to optima; the discovery that computational difficulty is not distinguished by linearity vs. non-linearity, but rather by convexity vs. non-convexity of objective and constraint functions; and use of conic programming. These innovations have given rise to *multi-stage, non-linear,*

31. "N-P hard" refers to a class of problems/algorithms whose computing time increases as a non-polynomial function, *i.e.*, hyper-exponential computing time.

stochastic programming—implemented in specialist software applications beginning in the late 1990s, and ultimately into Microsoft® Excel® plug-ins in the 2000s. These optimization techniques make it possible for Department leadership to create portfolio and acquisition strategies featuring flexible, adaptive system designs, and to rationally allocate resources across the primary development path, hedges, and recourse actions.

At the same time these operations research advances were being made, the systems engineering community began to adopt concepts and techniques from the financial community to help determine the economic value of flexibility and adaptability in system design. Since the 1980s, commercial industry used portfolio allocation techniques to value investment options in finance, drug research, and oil/gas/mineral extraction. Since the mid-1990s, options analysis has been applied to the design of real, physical systems.

Termed *real options analysis*, such methods illuminate the value of design features whose primary purpose is to provide the freedom for future design or capability enhancements. Classic examples include whether to invest in a stronger or larger foundation under a building (to allow for later additions/expansions), or to buy more right-of-way than is needed in the near-term for a transportation or resource distribution project. Real options analysis is currently used by roughly one-in-eight *Fortune* 500 corporations as an alternative method for evaluating investment payback for adaptive system designs. Under the right circumstances, real options analysis can value hedges, which may enable future recourse actions in system designs.[32]

Hedging enables adaptability. Hedging strategies offer several benefits to DOD. On tactics, techniques, and procedures, U.S. forces can train on the skill sets of multiple operational specialties in the event that a wider variety of skill sets may be needed. For example, ground forces that are expected to fight among populations will also require rudimentary policing skills. Hedging for systems can mean that long-lead research and development is conducted in order to provide a "jump start" to modifications, should they be needed in the future. Long-range planning must include "adaptability" as a specific metric in future requirements. Attributes associated with "adaptability" will include the means by which to pre-plan future modifications that increase system flexibility of use, configuration, tactics, and concepts of operation. An important point, frequently reiterated, is that the best hedge against operational uncertainty, in addition to training and

32. For example, see B. Miller and J. Clarke, "Real Options and Strategic Guidance in the Development of New Aircraft Programs," Real Options Conference 2005, and related research literature.

preparation, is broad education of operators on how to think, question, and understand the environment in which they are operating. (Appendix D offers a methodology by which a hedging strategy can help address uncertainty of DOD's Long Range Strike Family of Systems.)

Enhancing adaptability will require the Department to structure mission portfolios and defense acquisition programs to balance meeting current and future needs, and plan for flexibility in execution of these efforts. Hedging reduces investment by delaying decisions and pre-positioning the potential to rapidly respond to adversary moves, without investing for all possible scenarios. Hedging also reduces the adversary's ability to force DOD to invest in defending all vulnerabilities. Methods and tools now exist to create and budget for adaptive strategies and responsive execution of these programs.

Implementation Action: Establish rigorous processes to manage uncertainty in strategic planning:

- USD (AT&L) and Service Acquisition Executives **revisit requirements throughout system lifecycle**. Include both planned revisits at regular time intervals and event-driven revisits due to significant internal or external events.
- Program executive officers and program managers **expand scope of risk management in major acquisition programs:**
  - Incorporate exogenous risk sources (e.g., requirements, budget fluctuations countermeasures, etc.) into risk management plan.
  - Identify and maintain, subject to resource constraints, alternative courses of action for top risks.
  - Continuously and quantitatively estimate and track switching costs between alternative courses of action and baseline program plan.
- Service Acquisition Executives **develop and pilot analytical tools** to inform hedging decisions:
  - Leverage industry tools and techniques for real options analysis and stochastic non-linear optimization.
  - Office of the Director, Defense Research and Engineering, and Service Acquisition Executives develop standards and best practices.
  - Defense Acquisition University develop and promulgate curricula.
  - Conduct pilots/case studies on a mission portfolio and several programs (*e.g.,* Long Range Strike/Family of Systems).

Summary of Recommendations

USD (AT&L) and Service Acquisition Executives take steps necessary to align DOD enterprise functions to support mission outcomes. In doing so, recognize the needs of both rapid response timelines and hedging to manage the risk of uncertain futures.

To align programs of record to unit deployment:

- USD (AT&L) and Service Acquisition Executives or their designees organize **functional development teams** at the inception of each major acquisition program to align incentives and motivate timely delivery of capability to the war fighter.
- USD (AT&L) and Service Acquisition Executives require use of **trade space analysis** including simulations with operator input for all major system acquisitions before critical milestone decisions. Additional tools, such as mission rehearsal gaming, may also help clarify true system needs and paths to adaptability.
- USD (AT&L) direct that requirements processes for new systems and major upgrades provide for **open, modular architectures**, flexible design concepts, and interoperability.
- Enable rapid force adaptation through a **mixed-force structure of equipment and personnel**:
  - Combatant commanders and Service chiefs recast use of existing systems to build mixed-force fighting capabilities for near-term contingencies.
  - Joint Requirements Oversight Council rebalance materiel procurement quantities to enhance future mixed-force structure to meet mid-term needs.
  - USD (AT&L) identify research and development most critical to further enhancing a mixed-force for tactical contingencies and provide effective logistics.
- USD (AT&L) and Service Acquisition Executives implement a **block upgrade strategy** (pre-planned and unplanned) to continuously improve systems. Align programs, contracts, and budgets to support this approach.
- USD (AT&L) establish **flexible contracting procedures** designed to enable smart use of contractors over the life cycle of a program:
  - Enable tailored contracting processes to support rapid minor systems upgrades/modifications.

  - Encourage competition at the subsystem level through open system architectures.
  - Enable retention of critical skills to support orderly, continuous upgrades and surge capacity.
- USD (AT&L) **acknowledge the key role of contractors** in acquiring, fielding, and upgrading systems by putting in place incentives that motivate: on-time performance, enhanced field support for upgrades and deployments, design to support incorporation of user/operator lessons learned, participation in exercises and training.
- USD (AT&L) re-emphasize the need for **strong program managers** and take steps to strengthen capabilities:
  - Implement a strategy wherein program management offices have on-demand access to up-to-date management and technical experts as part of a formal mentoring process.
  - Direct DAU and the Service colleges to add faculty with experience in commercial best practices and supplement current faculty with advisors who have experience outside DOD processes.
  - Direct DAU and the Service colleges to strengthen the curricula by enhancing courses in technologies and commercial development practices in areas pertinent to major DOD acquisitions. Hire new faculty with experience in commercial best practices.
- DAU foster the creation of social networks for sharing information on program management experiences and process streamlining.

To enable rapid response:

- The combatant commands, working with the Joint Staff, develop a quicker and more effective process to **rapidly change TTPs and CONOPS** across units and Services. Such a process will require rapid and distributed collaboration among the users in the field with the help of experienced operators and system developers.
- **For rapid acquisition programs**, each Service transition to a single organization established similarly to the Air Force "Big Safari" program, with a small, very capable, and experienced staff of 20 to 50 people.
- USD (AT&L), working with the Service Acquisition Executives, create **forward-deployed engineering teams**, serving at the direction of the combatant commander, to efficiently triage operational needs, translate

them to actions, and effect fulfillment in days or weeks instead of months or years.

- USD (AT&L), working with the Service Acquisition Executives, quickly develop a **robust in-field system modification capability** for each Service. This capability will primarily address software upgrades, but may also include minor hardware upgrades.

To manage uncertainty in strategic planning:

- USD (AT&L) and Service Acquisition Executives **revisit requirements throughout system lifecycle**. Include both planned revisits at regular time intervals and event-driven revisits due to significant internal or external events.
- Program executive officers and program managers **expand scope of risk management in major acquisition programs**:
  - Incorporate exogenous risk sources (*e.g.*, requirements, budget fluctuations countermeasures, etc.) into risk management plan.
  - Identify and maintain, subject to resource constraints, alternative courses of action for top risks.
  - Continuously and quantitatively estimate and track switching costs between alternative courses of action and baseline program plan.
- Service Acquisition Executives **develop and pilot analytical tools to inform hedging decisions**.
  - Leverage industry tools and techniques for real options analysis and stochastic non-linear optimization.
  - Office of the Director, Defense Research and Engineering and Service Acquisition Executives develop standards and best practices.
  - DAU develop and promulgate curricula.
  - Conduct pilots/case studies on a mission portfolio and several programs (*e.g.*, Long Range Strike/Family of Systems).

Chapter 4. Reduce Uncertainty through Better Global Awareness

As discussed in the previous chapters, preparation is a key element of adaptability and the ability of the Department to ready its forces for future conflict. As part of a holistic examination of the concept of adaptability, the summer study focused on the role of intelligence and information support in preparing the Department of Defense and U.S. forces for armed conflict, emerging hot spots, and other critical challenges, such as cyber attacks and weapons of mass destruction (WMD)—as well as the potential for military engagement with an adversarial peer or near-peer.

The study found that the intelligence community has performed well and saved lives in supporting deployed military forces in ongoing land wars in Iraq and Afghanistan. It is less clear, however, whether the community would have been as successful and adaptable in different types of "environments," such as cyber, undersea, space, or conflict along the U.S. border. After nearly six months of review,[33] this study found three areas in which the Department and the intelligence community could make substantial improvements:

1. Providing predictive awareness about regions or problem sets that could become potential "hot spots."
2. The importance and growing role of open source as a force multiplier for adaptability, in DOD and the intelligence community.
3. Countering the full spectrum of foreign offensive capabilities targeting DOD information systems.

RECOMMENDATION: GLOBAL SITUATIONAL AWARENESS

Maintain and improve global situational awareness even in the presence of ongoing conflict.

33. This review of the intelligence community and its capabilities, conducted by the Intelligence Panel of the summer study, included briefings received from the Office of the Director of National Intelligence, the Defense Intelligence Agency, the National Geospatial-Intelligence Agency, the National Security Agency, the Central Intelligence Agency, the State Department, MG Mike Flynn, the Combined Joint Staff Branch for Intelligence (CJ2), the International Security Assistance Force Afghanistan, academia, and the private sector. A complete list of briefings is included in the list of presentations at the end of this report.

Focused Intelligence Support for Future Operations

Maintaining global situational awareness in parallel with ongoing hot war(s) has proven to be a tremendous challenge for the intelligence community. Hot war produces the so-called phenomenon of "everyone rushing to the soccer ball" wherein intelligence energies are disproportionally drawn to the conflict or immediate problem set. In doing so, the community runs the risk of missing other global indicators of emerging threats to peace or U.S. interests.

During the two land conflicts in Iraq and Afghanistan, the intelligence community demonstrated its adaptability and provided high-quality intelligence primarily through deploying hundreds to thousands of personnel into the area of operations. These personnel were supported by an increasingly integrated information infrastructure and a robust sharing environment among U.S. units and between the United States and its allies. Despite the superior performance eventually achieved, the Department and intelligence community can do better.

For instance, intelligence personnel deployed to overseas operations primarily as representatives of their respective agencies without prior integration or training with their interagency colleagues. This integrated intelligence apparatus was created in the theater, "on the fly," amidst an ongoing conflict. The *ad hoc* approach delayed or impeded the establishment of a fully functioning, well integrated team, something this study team believes could have happened before any intelligence personnel actually deployed. Furthermore, these two conflicts reflect many aspects of a traditional operating environment. Could the same adaptability have been demonstrated in different scenarios—cyber or space, maritime or undersea, domestic or U.S. border, denied or ungoverned areas, or where the United States is a bystander to a major conflict? Domestic threats (IEDs in the homeland, as in New York) or instability along our nation's border require a different set of skills and talent than what the intelligence community traditionally employs. The scale of investment in new technology around the world is increasing so fast that a new security environment is quickly emerging.

Our nation has seven and nine years, respectively, of hard work invested in the intelligence support structures and capabilities in Iraq and Afghanistan. These capabilities eventually proved extremely important in turning the tide against the insurgency in Iraq and are being commensurately effective in Afghanistan. However, the United States does not yet have the recipe perfected for conducting counter insurgency and stability operations in such areas.

A compelling paper, co-authored in January 2010 by Major General Mike Flynn, makes the point that while current, accurate, penetrating intelligence on adversaries is necessary for any military operation, the conduct of counter-insurgency, counter-terrorism, or stability operations in and among rural or urban indigenous populations requires much better intelligence about the economic, social, cultural, and tribal attributes of the geography and the population than the intelligence community had to that point been providing.[34] In speaking to the summer study members, Major General Flynn asserted that this kind of intelligence is not routinely produced for areas that might eventually be candidates for U.S. involvement.

Creating a process to produce such intelligence from scratch in the midst of an ongoing hot war is an extremely tough challenge. Thus, the summer study concluded that DOD and the intelligence community could improve the U.S. intelligence posture, prior to, during, and after outbreak of hot war in today's post-Cold War national security paradigm. Equally important, if not more so, is the opportunity to shape and influence circumstances prior to a conflict or problem set—in the hope of heading off or mitigating a particular problem.

Creating Intelligence Community Core Teams

Implementation Action: The Under Secretary of Defense for Intelligence (USD (I)), in coordination with the Director of National Intelligence (DNI), **establish small multi-agency teams to provide predictive awareness** and contextual understanding about regions or problem sets where the U.S. military might need to engage either unilaterally or with its partners.

No program or entity of this nature exists in the intelligence community or the Department of Defense today. This entity can be modeled after two small-scale efforts underway in the office of the DNI (ODNI)—the Summer Hard Targets Program (SHARP) and the Rapid Analytical Support and Expeditionary Response (RASER). These commendable programs help to address some of the concerns outlined earlier. However, neither effort is oriented to military requirements or is organized or staffed to support U.S. military engagements or U.S. military presence overseas.

34. Major General Michael T. Flynn, USA; Captain Matt Pottinger, USMC; and Paul D. Batchelor, DIA. *Fixing Intel: A Blueprint for Making Intelligence Relevant in Afghanistan,* Center for a New American Security, January 2010.

This new intelligence community capability, informed by the SHARP/RASER programs, would be designed to support both large-scale military engagements, as well as operations where Special Forces are deployed or where the nation is in the shaping or influencing stage, often referred to as Phase Zero. DOD and the intelligence community need to do a much better job of predicting and maintaining global situational awareness where a serious conflict or problem set could emerge, and have an intelligence community team trained and ready to deploy to support a combatant commander on day one of any such engagement.

The capability would comprise four to six core interagency teams (in the continental United States) who are trained to work across agency boundaries and are skilled in the areas that the nation is most likely to face: cyber, space and counter-space, WMD (chemical, biological, nuclear), counter-insurgency, identity management, biometrics and forensics, attribution, and others. The needed skills are unique to particular problem sets and require elegant and finite technical intelligence collection and analytical skills that are not easily replicated or employed in an interagency or coalition environment—especially in the midst of an ongoing overseas crisis or engagement. The specific teams established would be based on input from the National Intelligence Council and the DNI mission managers.

The DSB recommends that core teams be constructed through a "community of interest" model where separate organizational elements are not created and where team members are not required to collocate. Sufficient leadership constructs should be created to establish the required capabilities and to develop and manage relationships for conduct of deployments. Collocation of team members might be appropriate as a "lukewarm" issue or problem-set grows in intensity or significance. The evolving "A-Space" analytic sharing environment implemented by ODNI is recommended as a key element of supporting this new entity. Personnel of the caliber involved in the RASER or SHARP programs could help form the core of this entity; although, the myriad complex technical intelligence issues that DOD and the intelligence community are likely to face may require a different model.

As understood by the DSB, RASER is intended to develop and test innovative training, tools, and tradecraft to bolster existing capabilities and improve the intelligence community's ability to respond to crises that have the potential to require U.S. military action. The intent of the DSB's recommendation is to capitalize on and adapt the best practices of the RASER/SHARP programs; but, with a focus on military requirements and the potential to deploy overseas in support of Special Forces or military engagements. These core teams would be charged to develop

more comprehensive intelligence descriptions of areas of potential crises and problem sets than those confined to narrowly defined adversaries, their capabilities, and their intentions.

Such comprehensive intelligence (in some cases highly technical) is absolutely required for shaping and influencing operations both prior to and during a crisis. These operations are likely to be in disparate environments, lacking much of the infrastructure of the modern world; they may be conducted in and among rural and urban civilian populations, with languages, cultures, values, economies, and social structures different from western norms. Achieving the required comprehensive intelligence posture will require engagement with elements across the U.S. government, academia, other governments, and international nongovernment organizations. It may also require development of different methods to fully represent, analyze, and characterize data than have been used to work "threats" in the recent past. And, these teams should certainly draw more heavily on open source data, as is recommended elsewhere in this chapter. In fact, open source intelligence might provide the foundation for the comprehensive intelligence picture they would pursue.

Preparation and Deployment

As a complement to building comprehensive intelligence characterizations of potential worldwide crisis areas or problem sets, the DSB recommends that the new intelligence teams outlined herein be prepared as the "first responders" (prior to force deployment) for deployment to areas of emerging crises. As such, these teams must not only explore training, tools, and tradecraft, as noted above, they must develop organizational constructs, concepts of operation, infrastructure requirements (information technology, communications, and others), logistics, personnel support constructs, and institutional relationships, so that an initial cadre could be deployed rapidly, ready to begin integrated intelligence support. This initial cadre would then be fleshed out to full capability and sustainability in weeks, not years.

To achieve this level of readiness, the teams will need to be backed by working agreements documented in memoranda of understanding among the participating agencies or bodies. Additionally, the teams will require infrastructure test beds to validate required information technology and communications infrastructure; to demonstrate and validate concepts of operations, including mechanisms for reach back and interaction with the multiple involved stateside entities; and to explore

mechanisms for interaction with host governments, other significant indigenous governmental bodies, allies or coalition partners, and other governments.

While it will be important to have the best possible work up of the comprehensive intelligence picture of the area to which they are deployed, any such picture will inevitably be imperfect and incomplete. Once deployed, the teams would be well positioned to address those imperfections and provide critical intelligence support from day one—rather than scramble and organize overseas in the midst of a crisis, as has frequently been done. The work on developing the relationships, processes, and infrastructure before deployment should pay enormous dividends in terms of rapidly beginning mission execution rather than spending time and energy trying to work these issues in the field under the pressures and chaotic conditions of conflict.

This concept—new intelligence community teams, established for a manageable number of potential global hotspots, with the capability for select members to serve as intelligence community "first responders"—has the potential to provide DOD and the intelligence community with greatly improved global situation awareness. It will also provide a ready reserve of intelligence community assets who are equipped and trained, with required infrastructure, tools, relationships, and processes that are defined and validated, to hit the ground running in case of an emergency or crisis, thereby avoiding a slow, painful initiation of intelligence support wherever that may be. These deployable teams will significantly enhance our nation's ability to adapt to differing and emerging threats from day one of a crisis, rather than "reinvent the wheel" every time U.S. forces are required to engage—and, in doing so, will not only enhance adaptability, but also save lives.

The Importance of Open Source in DOD and the Intelligence Community

"They value most what costs most…"[35]

The information revolution sweeping the globe is clearly changing the nature of the game for DOD and the intelligence community. Dan Butler, the Assistant Deputy Director for Open Source, in the office of the DNI recently noted that "the poor man's intelligence community is now available to anyone with access to an Internet café or a Smartphone." How much information is out there? In 2009, the Internet was

35. John Le Carre. *Tinker, Tailor, Soldier, Spy*.

estimated to be about 500 exabytes (500 billion gigabytes).[36] As a point of comparison, the printed collection of the Library of Congress is estimated to be about 2 terabytes (2,000 gigabytes).[37] Eric Schmidt, Google Chief Executive Officer, recently estimated that the sum total of all human knowledge created from the dawn of man to 2003 totaled 5 exabytes—the amount now created every two days and accelerating.[38]

Mainstream search engines like Google and Bing index a small portion of the Internet. Current estimates place this at 27 billion WebPages.[39] The non-indexed portion of the Internet is called the "deep web" (also called deepnet, invisible web, dark web, or hidden web). The deep web includes dynamic content, unlinked data, and data protected from access by passwords. The deep web contains government reports, databases, and other sources of information of high value to DOD and the intelligence community. Alternative tools are needed to find and index data in the deep web.

Internet traffic and the volume of data stored have also grown exponentially. A recent report by CISCO suggests that global IP traffic will quadruple between 2009 and 2014, representing 767 exabytes of traffic per year (Figure 4-1).[40] This trend is likely to continue to 2020, driven by strong growth in visual traffic, data exchanged between sensor networks, and the increasing penetration of high speed Internet globally. Streaming visual media is expected to be the primary driver of Internet traffic growth over the next decade, through TV, video on demand, and visual communications.

Approximately 1.7 billion users were connected through the Internet in 2010, from a global population of 6.7 billion. The National Science Foundation forecasts that there will be almost 5 billion users online by 2020, a penetration of nearly 70 percent of the world's population. In the future, as information content technology becomes inexpensive, familiar, widely available, and well understood, digital content consumers will be demanding greater flexibility in their selection and use of information. These transformational effects are basic changes in the organization of a business and institution or user. Every organization will become an information machine in which the plans, organization, and operation of that machine are essential to its effectiveness, irrespective of what product or service it produces.

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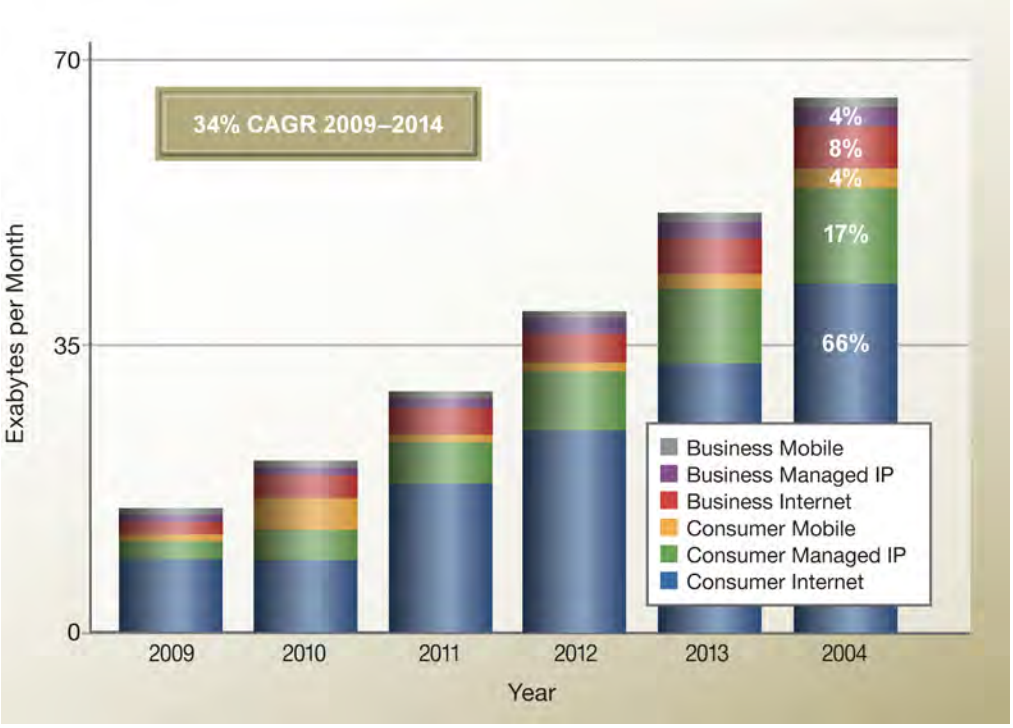
36. http://www.guardian.co.uk/business/2009/may/18/digital-content-expansion
37. http://www.jamesshuggins.com/h/tek1/how_big.htm
38. http://www.readwriteweb.com/archives/google_ceo_schmidt_people_arent_ready_for_the_tech.php
39. http://www.worldwidewebsize.com/
40. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/VNI_Hyperconnectivity_WP.html



Source: Cisco, VNI 2010

Figure 4-1. Global Internet Traffic

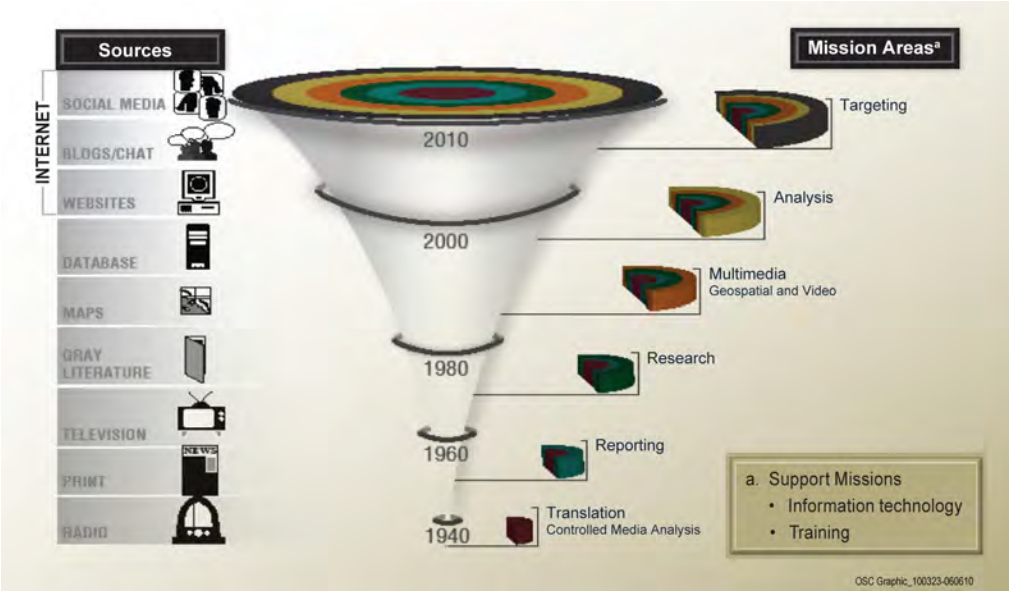
Karl von Clausewitz once wrote, "The first, the supreme, the most far reaching act of judgment that the statesman and commander have to make is to establish … the kind of war on which they are embarking; neither mistaking it for, nor trying to turn it into something that is alien to its nature."[41] To a degree, the unclassified world of the Internet, chat rooms, blogs, etc. is "alien" to the intelligence community's nature. Stealing the classified secrets of a potential adversary is where the community is most comfortable. Josh Kerbel, writing in a March 25, 2010 editorial noted, "In general terms, the IC's [intelligence community's] model is a secret 'collection-centric' one that:

- prizes classified data, with classification often directly correlated to value and significance;
- is driven by data availability, while analytical requirements remain secondary;

41. Carl von Clausewitz. *On War* (1831), ed. and trans. M. Howard and P. Paret, Princeton University Press, 1976, p. 75.

- is context-minimal, with analysts staying close to the collected data and in narrow account 'lanes';
- is current-oriented, since there are not collectable facts about the future;
- is warning-focused, emphasizing alarm-ringing;
- is product-centered, measuring success relative to the 'finished-intelligence' product provided to policymakers, rather than its utility or service."[42]

For these reasons, open source has traditionally been undervalued and underfunded in the intelligence community, though that is changing, albeit slowly. Recently the DNI's Open Source Center provided a "picture" (Figure 4-2) of the current open source environment.



Source: Open Source Center

Figure 4-2. The Current Open Source Environment

DOD and the intelligence community need to better understand the value of open source intelligence (OSINT)—how to exploit it, what to look for, where to look for it, and OSINT's role with respect to both collection and analysis. How does DOD take advantage of this vast "free" treasure trove of information? Data fusion is a huge challenge. DOD and the intelligence community are literally drowning in data, where valuable information is often immersed in irrelevant, misleading, or just bad data.

42. Josh Kerbel. "For the Intelligence Community, Creativity is the New Secret," *World Politics Review,* March 25, 2010.

Threat identification and characterization, individuals of interest, and pattern analysis are probably among the highest growth areas for the exploitation and use of open source. How should the community organize and prioritize today to make the most efficient use of open sources in the next 10 years? Does it have the sophisticated data-mining and analytical/collection tools needed both today and in the future to process and sort out what is really important and actionable? Critical thinking and open source tradecraft will need to be constantly improved so that analysts will be able to discover the clever ways that adversaries are utilizing open source—both to get their "message" out as well as to understand what they are really saying. Analysts need to be encouraged to openly interact with outside experts and to build broader and deeper knowledge than the current collection and analytical structure permits.

Open Source and DOD

The *Defense Science Board 2004 Summer Study on Transitioning to and from Hostilities*[43] made recommendations calling for much more broad use and exploitation of open source intelligence. Other DSB reports such as the *Report of the Defense Science Board Task Force on Strategic Communications* (September 2004)[44] and the *Report of the Defense Science Board Task Force on Understanding Human Dynamics* (March 2009)[45] mention the need for a coherent DOD approach to OSINT. But those reports did not sufficiently emphasize the need to develop OSINT tradecraft for both collectors and analysts, nor did they underscore the importance of the links between the data, tools, analysis, and tasking that is inherently part of OSINT.

In order to develop a common OSINT plan to address the gaps, DOD requires methodology, tools, and processes that are not bound by individual analytic problem sets. Solutions must deliver a mechanism and architecture that is flexible enough to surge and share information within bounds of copyright, exploitation, and collection and analysis capabilities to meet multiple languages and topics. Solutions must also include a dissemination capability able to reach a broad range of customers in their native environments.

The 2006 National Defense Authorization Act directed OSD to develop a strategy to improve integration of OSINT into DOD intelligence. In 2007, the Under Secretary of Defense for Intelligence (USD (I)) designated the Defense Intelligence Agency

43. http://www.acq.osd.mil/dsb/reports/ADA430116.pdf
44. http://www.acq.osd.mil/dsb/reports/ADA428770.pdf
45. http://www.acq.osd.mil/dsb/reports/ADA495025.pdf

(DIA) as the entity responsible for overseeing the Defense Open Source Enterprise, and for ensuring DIA collectors, analysts, and operators have access to open source capabilities. DIA established the Defense Open Source Program Office (DIOSPO) in 2008 with the mandate to:

- Advise USD (I) regarding OSINT matters.
- Establish DOD standards for the collection and dissemination of OSINT.
- Prioritize DOD open source requirements consistent with the National Intelligence Priorities Framework (NIPF).
- Evaluate DOD open source programs to ensure they are consistent with National Open Source Committee guidelines.

DOD open source stakeholders range from the Assistant Deputy Director of National Intelligence for Open Source at the strategic level, to the combatant commands and the war fighter at the operational and tactical levels.

While substantial progress has been made, the Defense Open Source Program remains fragmented with no real means to affect the larger intelligence enterprise without a strong and resourced DIOSPO. Unfortunately, despite being established in 2008, the DIOSPO only reached full operating capability in April 2010 when it was "fully staffed" with 14 people. In addition to this very undermanned office, defense intelligence program funding for DIOSPO is minimal. In 2009, DOD had 62 percent of national OSINT requirements but only 3 percent of OSINT funding. Moreover, defense open source has only 14 percent of the intelligence community OSINT manpower and, of that, 68 percent is funded through supplements to the defense budget. The Defense Open Source Council, which is the governing body for prosecuting DOD's open source strategy/campaign, has seen uneven participation or cooperation from the military services, combatant commands, and defense agencies—with representation sometimes left to junior members without the authority to make decisions for their organizations.

The few programs with baseline resources dedicated to open source are facing significant cuts, such as the National Media Exploitation Center (NMEC) and the National Air and Space Intelligence Center (NASIC) Special Collections Library, which has lost more than a third of its funding in the last five years. The potential for in-depth exploitation of the Special Collections Library's more than 9,000 foreign science and technology journals and hundreds of databases is vast, but to date only small, focused (and very successful) projects are underway. With a comparatively small investment, this capability could be expanded to address a number of national security issues.

NMEC supports both open source and classified exploitation of materials seized on the battlefield and elsewhere. It is a one-of-a-kind capability established by the DNI in 2002 as a service of common concern to support the information needs of the intelligence community, law enforcement agencies, the Department of Homeland Security, and the Department of Defense war fighting commands and policy-makers through advanced document and media exploitation. NMEC has been instrumental in providing critical intelligence support in the areas of advanced forensics (processing/exploiting communications equipment captured on the battlefield); regional, cultural, and linguistic analysis and translation capabilities covering 32 languages and all global "hot spots"; highly advanced digital communications architecture capable of storage and rapid search of immense volumes of information and near-real-time dissemination to customers worldwide; and conducting modification of leading-edge research and development for state-of-art data search, retrieval, exploitation, and dissemination technology. Although NMEC is viewed by its interagency partners as a unique and critical national intelligence asset, approximately 80 percent of its operations are conducted with supplemental funding, threatening its existence beyond the two land wars underway today.

With appropriate resources OSINT can serve as a force multiplier to help address intelligence gaps in many of DOD and the intelligence community's most challenging analytic areas. This kind of effort will be critical for supporting the small deployable intelligence community teams that will be ferreting out surprise and working on shaping the environment, attaining the deep cultural understanding of the environment, and monitoring and assessing the emerging threats or problems sets around the world.

Implementation Action: The Director, Defense Intelligence Agency **enhance the Defense Intelligence Open Source Program** in conjunction with the ODNI Open Source Center:

- Significantly increase exploitation and actionable output.
- Focused on war fighter, operational, and acquisition community interests.
- Need for advanced analytics to exploit large data sets.

USD (I) work with ODNI Open Source Center to establish and promote DOD open source "bureaus":

- Modeled along the lines of the Asian Studies Detachment, Camp Zama, Japan.
- Command/geographic specific, *i.e.*, Joint Analysis Center Molesworth, United Kingdom; Qatar; Romania.

As supplemental funding decreases, Director DIA ensure sufficient funding for the National Media Exploitation Center to support both open source and classified needs.

In order for the Defense Open Source Program Office to realize its full potential and provide the critical open source support for DOD and the intelligence community, this study recommends that the Director, DIA substantially enhance DIOSPO in conjunction with the ODNI Open Source Center. The DSB also recommends that a "true" DIOSPO be established, which would include a Defense Open Source "Skunk Works" entity within the DIOSPO. The Defense Open Source Skunk Works element should be modeled along the lines of the very successful Central Intelligence Agency (CIA) Open Source Skunk Works (OSW) office established in 2007. The CIA OSW is considered an innovation facility vital to cutting edge open source tradecraft that has provided 25 products to date—and it has received extremely positive feedback from its customer base as to its relative value. DOD could receive similar benefits from such a capability targeted against cutting-edge military R&D of U.S. peers, near-peers, and adversaries.

DOD should also strongly consider establishing one- or two-person Open Source Bureaus, modeled along the lines of the Asian Studies Detachment, Camp Zama, Japan. These bureaus should be command/geographic specific, *i.e.*, Qatar, Joint Analysis Center Molesworth, and Romania. Such one- or two-person bureaus could be staffed by expatriates; provide, over-time, early warning of a potential crisis or emergency; and disseminate data to the intelligence community teams that are created to focus on emerging threats and problem sets. Open source capabilities and bureaus based with the combatant commands should meet specific theater requirements, *i.e.*, U.S. Pacific Command's Asian Studies Detachment; U.S. Strategic Command's Foreign Media Analysis; and U.S. Central Command's OSINT office. These efforts should fit into an overall DOD OSINT strategy that DIOSPO should produce and orchestrate.

Finally, as supplemental funding decreases, the DIA director should ensure sufficient funding for the critical open source intelligence producers, such as NMEC and the NASIC Special Collections Library. Much of the increase in funding and resources can be captured through reallocation or decrements to other intelligence community programs.

DOD and defense open source is close, but the pieces are disconnected and their principal OSINT program office in DIA is understaffed, under-resourced, underfunded, and not well supported from the rest of the defense enterprise. If DOD is to take full advantage of the growing importance of open source, DIA needs to take demonstrable and immediate action to properly posture itself for this most important and emerging discipline.

Mission Assurance in a Dangerous World

Modern information technology has revolutionized every aspect of warfare. The increased capability of the U.S. military based upon the pervasive utilization of advanced technology is staggering. Weapons, communications, sensors, bandwidth, computing, precision navigation and timing, and situational awareness are examples of technologies and capabilities integrated into DOD systems that have enabled the most effective and overpowering military in the world. Modern information technology is also central to DOD's ability to prepare for conflict and to adapt appropriately to combat realities once engaged. Nearly all of these capabilities are made possible by, or highly leverage, COTS technology. The advantages are so profound that the continued utilization of advanced COTS–based technology is highly likely to continue into the distant future.

Unfortunately, there is rarely a "free lunch." DOD's dependence on COTS technology is so ubiquitous that its ability to project military force is put into question if denied the use of these capabilities. While the advantages of leveraging COTS technology are apparent, the associated risks are less evident and less appreciated. Today, most COTS technology involves significant foreign participation in every part of the technology life cycle. Design, development, implementation, testing, production, packaging, and distribution of the technology are laden with foreign contribution. Each of these foreign contributions provides for the introduction of vulnerabilities that can neutralize the military benefit. Consequently, the adversary places a high priority intelligence target on penetrating, corrupting, and degrading the DOD information technology infrastructure. If successful, the adversary levels the military playing field. Thus, if our nation is to maintain its military advantage, DOD must find ways to mitigate these threats.

Over the last several years, numerous studies and papers have highlighted the challenges associated with effectively defending DOD's information technology infrastructure from a dedicated and well resourced opponent. The bad news is that the Department has only marginally improved in its ability to defend these systems today, while its opponents are significantly more effective at attacking and exploiting these same systems. The good news is that a growing number of senior officials within the DOD, the national security establishment, and the civilian leadership are becoming aware of the magnitude of the challenge and the implications associated with failing to resolve them.

Sophisticated threats (actors with intent to do the United States harm) utilize a full spectrum of capabilities to target and exploit DOD information systems and components.[46] Examples of the full spectrum of capabilities in the tool bag include: traditional human espionage, surreptitious entry, supply chain, clandestine technical collection, open source, and cyber mechanisms. By utilizing a combination of these tools, an adversary identifies systems and/or components that, if exploited, would provide military advantage. These same tools can be used to discover an inherent vulnerability that can be exploited or, if not present, operationally introduce an exploitable vulnerability. During peacetime, these operations are used to acquire detailed knowledge of the systems. During crisis, the acquired knowledge can be used to degrade the functionality of U.S. systems, thus denying use of a system and reducing confidence in the military usefulness of other systems.[47]

Using these techniques, adversaries have repeatedly and routinely penetrated unclassified U.S. systems. The penetrations that have been observed usually take advantage of inherent vulnerabilities, connected machines, and targeted social engineering. These relatively simple foreign operations have successfully exploited DOD, the defense industrial base, and the U.S. commercial sector (such as the recent Google incident).[48] It has not gone unnoticed, by either U.S. opponents or by senior DOD officials and civilian leadership, that a significant percentage of the information technology systems, upon which the United States depends to project military force and conduct war, run in unclassified systems. Thus, these unclassified information technology penetrations (of which sophisticated practitioners are capable, almost at will) reduce our nation's military advantage, decrease confidence in the outcome of conflict, and weaken the utility of U.S. military strength as a deterrent.

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46. The more sophisticated threat will utilize a collection of human and technical capabilities to achieve its objectives. While the list is not intended to be comprehensive, it does illustrate that the high-end threat has a variety of capabilities that when effectively used in combination pose a very serious challenge to U.S. national security systems. Our nation's current defenses are inadequate. The array of capabilities include: surreptitious entry, spies, signals intelligence, clandestine technical collection, cyber mechanisms, foreign partners, deception, and cover companies. These formidable capabilities are woven into an operational framework that plays out over time, in various parts of the world, and, in combination, to threaten a very broad spectrum of targets, not just computer networks.

47. Interestingly, it may be in the best interest of the opponent for the United States to know the reason the system did not function was due to their operational intervention. Based upon this insight, the United States may begin to wonder what other systems have been altered.

48. In January 2010, Google accused China of orchestrating a major espionage attack targeting Google's computer systems, resulting in theft of intellectual property and monitoring of human rights activists' accounts in China, the United States, and Europe. Some 34 large firms, including Google, were reportedly successfully penetrated during this event.

A senior officer operating in Afghanistan conveyed to this summer study that his tactical dependence on the unclassified systems was extreme. Based on this position, he stated that "the high side is the low side." Unfortunately, the penetrations are not restricted to these unclassified systems. There is increasing evidence that adversaries have compromised both Secret and Top Secret systems. These exploits take advantage of unintended connections between classified and unclassified systems, intentional connections—using information technology guards and cross-domain solutions—and clever air gap jumping techniques that breach into these ostensibly isolated systems.

While attribution to a responsible party in these cases is very challenging, there is sufficient evidence to support that foreign actors are very actively engaged in targeting and exploiting U.S. systems. These countries' intelligence services are competent and aggressive. They understand the military return on investment for these operations and their impact on leveling the playing field. The probability of detection is low, the probability of attribution even lower, the consequences to the adversary of detection and attribution are non-existent, and the utility to the adversary of the operations is very high. Thus, it is fair to assume that these activities will not only continue but most likely increase in both frequency and severity. It is also important to note that the United States is not just vulnerable to potentially hostile adversaries. Nations that are friendly to the United States also have advanced capabilities and are strongly suspected of having penetrated U.S. systems. One would assume that such penetrations are not intended to cause a serious threat to U.S. interests, but this vulnerability is disquieting and there is always the possibility of harmful, unintended consequences.

In order to maintain our nation's military advantage, increase confidence in the proper operation of U.S. systems, and increase adversary uncertainty in the utility of their operations, the U.S. intelligence community must aggressively engage to defend its communication systems, situational awareness systems, command and control systems, precision navigation and timing systems, acquisition systems, logistic systems (airlift and sealift), and weapon systems. Without the aggressive and innovative use of offensive capabilities to support critical defensive objectives, effective risk management of these vital systems is simply impossible.

At the same time the intelligence community must use the full spectrum of its offensive capabilities to gain understanding of the opposing offense. These efforts

should yield deeper insight into the full spectrum of adversary capabilities, as well as their intentions, targets, risk tolerance, key players, key partners, organizational structure, and budgets. In turn, this enhanced insight should enable the community to apply limited resources, identify defensive shortfalls, task collection, inform policy, and inform research. The key is actionable intelligence. What do the owners and operators of these critical systems need to know to better defend the information technology life blood?

Figure 4-3 illustrates the necessary elements required to understand the threat, U.S. vulnerability, effectiveness of static protection, and the insight gained from hunting for adversaries within U.S. systems. It also shows the interplay between the elements. This information is synthesized within the analysis function and informs the situational awareness operations center. The network operations center uses the knowledge to dynamically adjust information technology resources to meet user demands while, at the same time, minimize the impact of the opponent's activity.

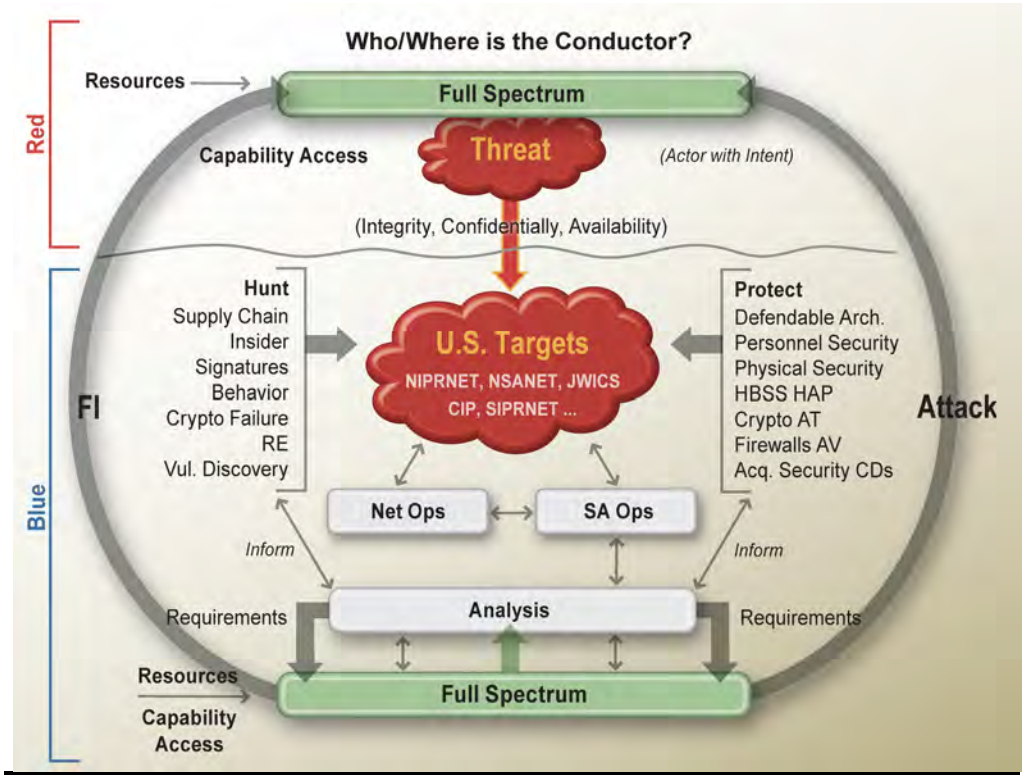


Figure 4-3. Key Elements in Understanding the Information Technology Threat

There is an increased level of understanding of the criticality and complexity of information systems and of the threats arrayed against them. However, tactical decisions are being made throughout the chain of command that do not reflect understanding of the strategic implications that those decisions have on our nation's ability to protect its information technology enterprise. Since the United States' ability to fight, win, and adapt significantly depends on its ability to defend the enterprise, these local decisions made for tactical advantage can have devastating, unintended consequences.

If a commander decides to share TS/NOFORN (Top Secret/Not Releasable to Foreign Nationals) information with a coalition partner in order to solve a tactical problem in the field by providing that partner with direct or indirect access to the information technology system, a path is provided for that partner (or any other body that has penetrated that partner) to compromise the system and all content and other systems to which it is connected. The perspective, "I would rather be judged by 12 than carried by 6," is understandable, and perhaps justifiable, if the local decision has only local ramifications. However, the impact of these potentially uninformed decisions frequently has adverse impact well beyond the battlefield that can be enduring.

To defend these mission critical systems, the U.S. intelligence community must be actively engaged and resourced to collect, analyze, report, and thwart the threat. Additionally, to increase the likelihood that these decisions are made with the right balance between benefit and unintended consequences, training and education is needed throughout the entire chain of command on how adversaries target and exploit U.S. systems, the limitations of our nation's defensive strategy, the strategic implications of system compromise, and related topics.

Progress is being made in all of these areas but much more is needed. A first step that should be taken to improve the U.S. defensive posture is to increase the priority and visibility of these issues within the NIPF. The Director of the National Security Agency and the National Intelligence Officer for Science and Technology should collaborate to increase this priority. Additionally, since the combatant commander is ultimately responsible for mission assurance, the threats, mitigation activities, and residual risks need to be conveyed and understood. Only then can the combatant commander plan and act with confidence.

Implementation Action: Raise the priority on **understanding DOD information system penetration**. Fill substantial gaps in understanding of adversaries' full-spectrum capabilities to target DOD information systems—intentions, targets, risk tolerance, key players and partners, organizational structures, budgets, tools:

- Director of the National Security Agency and the National Intelligence Officer for Science and Technology address through the National Intelligence Priorities Framework process with appropriate collection managers.
- Anticipate threats to key capabilities that enable effective contingency responses: communications networks; logistics systems; precision navigation and timing; global intelligence, surveillance, and reconnaissance.

The focus of this study is DOD adaptability. Adaptability is inextricably intertwined with defense of DOD's information technology systems. The complexity and extent of this defensive challenge is well beyond the terms of reference of this study, but the challenge is serious. The DSB strongly recommends that the Department initiate a comprehensive study of the problem. Only then will DOD have confidence that it understands the challenge and threats well enough to mount the required defenses.

Summary of Recommendations

Maintain and improve global situational awareness even in the presence of ongoing conflict.

To improve predictive awareness:

- USD (I), in coordination with DNI, **establish small multi-agency teams to provide predictive awareness** and contextual understanding about regions or problem sets where the U.S. military might need to engage either unilaterally or with its partners.

To make better use of open source intelligence:

- The Director, DIA **enhance the Defense Intelligence Open Source Program** in conjunction with the ODNI Open Source Center:
  - Significantly increase exploitation and actionable output.
  - Focus on war fighter, operational, and acquisition community interests.
  - Need for advanced analytics to exploit large data sets.

- USD (I) work with ODNI Open Source Center to establish and promote DOD open source "bureaus":
  - Modeled along the lines of the Asian Studies Detachment, Camp Zama, Japan.
  - Command/geographic specific, *i.e.*, Joint Analysis Center Molesworth, United Kingdom; Quatar; Romania.
- As supplemental funding decreases, Director DIA ensure sufficient funding for the National Media Exploitation Center to support both open source and classified needs.

To raise the priority on understanding DOD information system penetration:

- Fill substantial gaps in understanding of adversaries' full-spectrum capabilities to target DOD information systems—intentions, targets, risk tolerance, key players and partners, organizational structures, budgets, tools:
  - Director of the NSA and the National Intelligence Officer for Science and Technology address through the National Intelligence Priorities Framework process with appropriate collection managers.
  - Anticipate threats to key capabilities that enable effective contingency responses: communications networks; logistics systems; precision navigation and timing; global intelligence, surveillance, and reconnaissance.

Chapter 5. Prepare for Degraded Operations

Even the most adaptable organization can expect to be confronted with the need to operate in degraded conditions. Degraded operations are those in which the anticipated environment, force capabilities, events, competence, or system performance depart from plan or expectation enough to require unanticipated actions and measures to achieve objectives or to abort the mission. Degradation can occur across a range of critical support systems, including:

- communications
- cyber networks
- space intelligence, surveillance, and reconnaissance (ISR)
- space precision, navigation, and timing (PNT)
- air, ground, and sea ISR
- electronic warfare
- stealth capability
- logistics

Commanders must consider the impact of adversaries' actions, equipment failure, natural factors such as weather, miscommunication of intent, and other factors. Adaptation to degraded conditions can occur across different timeframes, may arise from external and/or self-inflicted causes, and can occur at any and all levels—strategic, operational, tactical, and individual. Examples of various degraded circumstances at each of these levels are as follows:

- **Strategic**. Uncertain or not well understood end objectives and strategy, poorly estimated allied/coalition support and capabilities.
- **Operational**. Failure to understand logistical needs and vulnerabilities, failure to understand the impact of physical environment.
- **Tactical**. Loss of communication or Global Positioning System (GPS); limited access or resupply, ISR, fire support.
- **Individual**. Loss of sleep, combat stress, exhaustion.

This chapter discusses preparation for degraded operations in four areas: training and exercises, red and blue teaming, cyber and space, and individual adaptability and human performance.

RECOMMENDATION: PREPARE FOR DEGRADED OPERATIONS

Prepare for degraded operations by institutionalizing the use of realistic training and exercises and red/blue teaming to prepare for uncertain conditions.

Training and Exercises

The unpredictable nature of war requires military forces to be adaptable. In response to surprises on the battlefield, such as unexpected enemy forces or capabilities, equipment that did not operate as intended, support forces that failed to materialize, or changes in the nature of the battlefield environment, military commanders, units, and individuals have always had to adapt and adjust their plans to ensure mission success. Degradation begins at the moment of first contact with the enemy, and often before, due to harsh environments or "friction" in operations. This study examined training and exercises to prepare for degraded operations at the tactical and operational level.

Tactical Level Training

Recognizing the military imperative to be prepared to "adapt" and adjust to unexpected conditions on the battlefield, military leaders routinely include the need to adapt as part of the training regime. As training progresses beyond basic and team skills development, trainers begin to introduce the "fog of war," where forces train to deal with the unexpected and adapt their plan, tactics, and actions accordingly to ensure mission success. As such, it is not surprising that this study found that the military departments prepare well to adapt and operate in degraded environments at the tactical level. While the degree of sophistication used in creating the degraded environment varies among the examples examined, tactical training in degraded environments was evident and emphasized in every Service.

U.S. Air Force

Within the Air Force, training conducted on the Nellis Air Force Base range complex north of Las Vegas, Nevada (specifically the Red Flag series of exercises and the USAF Weapons School curriculum), highlights how the Service currently trains its crews to adapt and operate in degraded environments. In the lead-up to these training events, the Air Force analyzes current and projected threats; determines what vulnerabilities they may have; and develops appropriate tactics, techniques, and procedures to counter and defeat these threats (Figure 5-1).

Figure 5-1. Air Force Red Flag Training

These TTPs are practiced and honed by participating Red Flag crews. At the same time, additional TTPs are developed to help crews plan and execute their mission in a degraded environment or with degraded systems. For example, crews are tested to operate when communications and electronic jamming occur. Crews are forced to operate with and without onboard systems (*e.g.,* Link 16 and GPS) to train them to use back-up systems and procedures. Degradation levels are pushed to the point at which crews would be forced to abort their mission.

To create a degraded environment, the Air Force uses a combination of realistic training communications jammers with "white card" injects where it is impractical to actually jam the targeted system (*e.g.*, GPS, which is also used by civilian air traffic). While white card injects are considered effective in training crews to operate without certain systems, they fall short in teaching crews to recognize system degradation and when to revert to back-up systems or TTPs, creating a preparedness shortfall that may be deadly if encountered during a real mission.

U.S. Marine Corps

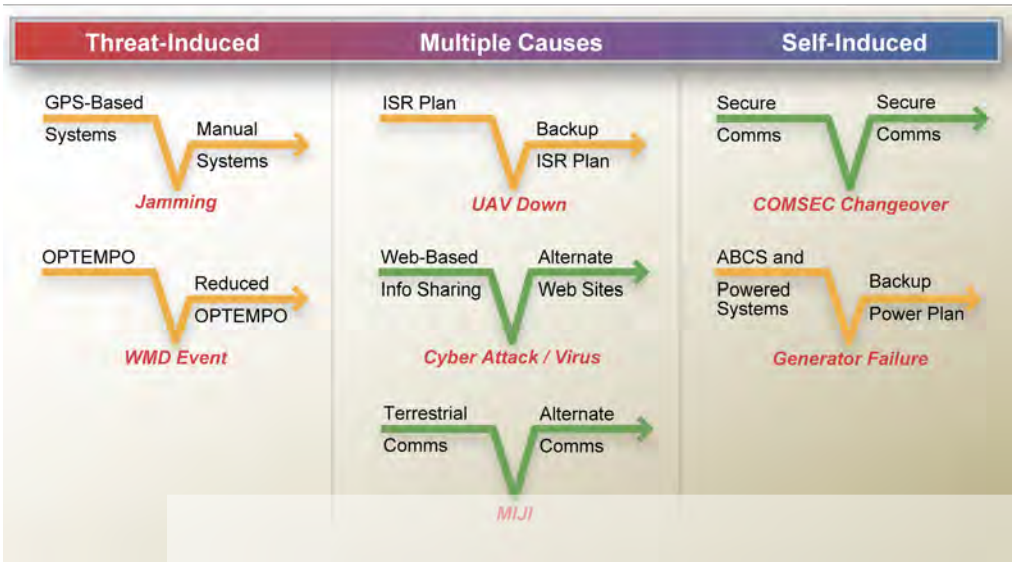
Marines take pride in their adaptability at the tactical and individual level. To better understand their success, the Marine Corps has partnered with the Army to correlate ties between training and adaptability. Due to the dynamic nature of the Marine mission, doctrine is evolving to "Enhanced Company Operations," to push command authority to levels below battalion. Training has been refocused on decision-making at the company and squad level, and developing the ability of the

team to quickly adapt to emerging battlefield scenarios. Repetition in training helps Marines learn from their mistakes and build a base of experience from which to adapt responses to future battlefield scenarios. Because of the current threat in Afghanistan and Iraq, much of current Marine training focuses on responding and adapting to the IED threat and on the demands of the "three block war" in which cultural sensitivity and humanitarian assistance may be required in parallel with combat operations.

U.S. Army

After a long history of conventional training and operating principally to rigid and restrictive doctrine designed to defeat such threats as NATO faced in Europe with Warsaw Pact armored forces, the Army has revised its operating doctrine to better prepare its soldiers to address the wide range of threats currently facing the United States. As part of this shift to "full spectrum operations," Army doctrine is designed to prepare soldiers to address conventional, insurgent, and criminal activities simultaneously across a broad range of engagement environments to include population centers similar to those seen by soldiers today in Afghanistan. The doctrine further addresses not only lethal operations, but also non-lethal and information operations.

The Army's Combat Training Center Directorate, part of the U.S. Army Combined Arms Center, is charged with translating the new doctrine into effective training environments and programs, whether for commanders and their staff (at Ft. Leavenworth, Kansas) or for brigades (at the National Training Center at Ft. Irwin, California, or the Joint Readiness Training Center at Ft. Polk, Louisiana) with a focus on mission readiness and rehearsal prior to deployment. The opposing force is equipped with assets (*e.g.*, communications devices, jammers, radar, trucks, and weapons) and employs tactics that realistically mimic the best intelligence about the local enemy, including evolving IED threats and tactics. In addition, cyber attacks, loss of power and/or ISR capabilities, WMD events, and similar challenges are injected into training events (Figure 5-2). The DSB was further impressed by the feedback process accompanying training events, in which a post mortem is conducted by the entire team. Every team member, regardless of rank is expected to contribute his or her critique of what went right and what did not.



Source: U.S. Army Training and Doctrine Command

Figure 5-2. Combat Training Center Scenarios for Degraded Operations

The Army Center for Lessons Learned also contributes to adaptability in the force. The center is intended to support real-time adaptation and has made significant progress in helping to support deployed soldiers and prepare deploying soldiers to adapt to the rapidly changing environment in Afghanistan. As threats and issues are identified (*e.g.*, a new IED tactic), the center stands up a team of experts to address the issue and develop/modify appropriate tactics in the field. Focusing on the forces most physically engaged, at the battalion level and below, the center rapidly disseminates the newly developed TTPs to field units, both those deployed and those preparing to deploy. The center then continues to test these newly developed TTPs as part of its experimentation program ultimately sharing it with other joint, interagency, and coalition forces where appropriate. Should a lasting change in the training environment be needed, the center then feeds that back to the Training Center Directorate.

U.S. Special Operations Command

In addition to the Services, the DSB examined U.S. Special Operations Command's (SOCOM) training regime and its approach to training forces to operate within degraded environments. As with the Services, SOCOM's training was found to be most successful at the tactical level where forces routinely trained with degraded communications and without GPS. SOCOM even conducts live-fire

training (with appropriate safety precautions) in a "comms-out" or fully degraded communications environment.

SOCOM has taken steps to make their training scenarios and environments as realistic and relevant as possible. Recognizing that the most dynamic threat environment in the current fight is in urban areas, SOCOM has incorporated real-life civilian players in communities local to their training centers into their Realistic Urban Training program. Each training scenario represents a dynamic environment in which the trainees must react in real time to both adversary and neutral civilian actions—an effective way to test the adaptability of the tactical training audience.

Like the Army, SOCOM recognizes the value of battlefield lessons learned and the critical need to update training in a timely manner. As lessons and appropriate tactics are gathered from the field or elsewhere, SOCOM immediately releases them to the field and training centers for incorporation into training and operations. One example noted was SOCOM's efforts to quickly disseminate the latest site exploitation TTPs. Through a web-based system, they disseminate the latest in biometric, forensic, document exploitation, and media TTPs to ensure that deployed forces have information on the latest exploitation techniques available. SOCOM reported concerns that funding limitations might force cutbacks to parts of their lessons learned program.

Operational Level Exercises

While the Services and combatant commands generally do a good job of training their forces to adapt to degraded environments at the tactical level, this study found a serious shortfall at the operational, large-force level based on review of eleven operational exercises (Table 5-1). At the operational level, the training objectives for all players aggregate and build upon each other (*e.g.*, company-level objectives fold into and support battalion-, brigade-, division-, and corps-level objectives), thereby creating complicated exercise scenarios. Free play in response to degraded environments creates a risk that planned exercise objectives may not be achieved. In addition, degraded environments are more difficult to emulate at the operational versus tactical level.

Table 5-1. Operational Exercises Reviewed

Exercise	Lead	Purpose	Degraded Operations
Red Flag	Air Force	Operational readiness and training	Sensor and comm jamming, limited GPS and cyber degradation
Terminal Fury	PACOM	Operational readiness and cyber security	Significant degraded comms and cyber networks
Army Mission Readiness	Army	Operations and tactics	Some comm and GPS jamming Limited cyber attack
Bulwark Defender	STRATCOM	Cyber mission readiness	Some cyber network degradation
Emerald Warrior	AF Special Ops	Integrated tactics/ command and control	Limited
Empire Challenge	JFCOM	ISR sensor and network demonstration	Limited degraded comm and networks
Global Lightening	STRATCOM	Strategic deterrence/ cyber and space	Some cyber and space degradation
Global Thunder	STRATCOM	Exercise/train nuclear forces	Limited
Javelin Thrust	USMC	Combat and logistics	Some severe terrain and environment
Joint Exp Force Exercise	Air Force	Integrated tactics/new concepts	Electronic warfare Limited comm degradation
Missile Defense Ground Tests	MDA	Operational readiness	Limited

For example, it is difficult to interfere with the GPS signal over a large exercise area without impacting civilian air traffic or other navigation systems within the same GPS satellite footprint. As a result, degradation, when it is introduced, is typically limited to "white card injects" that do not allow the training audience to be trained on how to identify and address the emergence of a subtle or evolving degraded event. Examples include limited and seemingly random denial of service, partial compromise or corruption of capabilities or information and data, unexpected enemy tactics, and widespread outages that appear to be produced by natural phenomenon. Despite this difficulty, there is some evidence that the Services and combatant commands are developing techniques to better train their forces to adapt and operate in degraded environments.

The Air Force's Red Flag exercises, as noted in Table 5-1, did a good job of presenting their training audience with a wide range of degraded scenarios. From the crews themselves to the Combined Air Operations Center (CAOC) planning the air battle, each is forced to adapt and execute in the face of unexpected degraded scenarios. The training is good but could be made better with the ability to create more realistic (especially subtle) presentations of degraded environments in the air both to the crews flying the missions and to the ground elements, such as the CAOC, supporting and planning the air battle.

Other training examined by the study exhibited varying levels of success. Despite the institutional shift in emphasis to full spectrum operations, the Army noted that in response to the growth of training objectives for units deploying to Iraq and Afghanistan, the amount of time available to conduct training in degraded operations was becoming ever more limited compared to the past. As with all Services, most large-force exercises are largely scripted to ensure training objectives are met; as a result, there is little room for free play or the introduction of red teams. One particular bright spot was the conduct of training at the National Training Center, where forces faced a very capable opposing force typical of Iraq and Afghanistan, with the feedback process described above, and a wide spectrum of training scenarios designed to test and train forces to operate in dynamic degraded environments. SOCOM noted that their training at the operational level was limited to staff exercises, and even then it was still at the "crawl" level with a focus on continuity of operations and without realistic cyber or degraded communications outages.

Of the eleven major unified command- and Service-level exercises examined, there was only one, Terminal Fury 2010, a recent U.S. Pacific Command (PACOM) exercise that truly incorporated operating in degraded environments as part of its exercise design and objectives. Unlike the others, Terminal Fury's overall objective was not only operational readiness but also cyber security. As such, it incorporated operating with degraded communications and cyber networks as part of the overall training objectives and included realistic degraded cyber events and environments.

Training and Exercises Recommendations

Implementation Action. Services' training commands develop approaches for realistically emulating degraded environments.

Recognizing the reliance on command and control systems and the high likelihood that future enemies will attempt to degrade them, the DSB urges the Services training commands and test ranges to assess the options and implement the most cost-effective approach for employing localized GPS jammers (Figure 5-3) and for building training networks that emulate command and control systems that can be realistically degraded and/or corrupted. Creating both training capabilities will allow training audiences to experience the subtle cues associated with a degradation attack other than a pure denial of services and to practice their procedural response and associated TTPs.

Implementation Action. Combatant commanders direct that future operational-level exercises incorporate operating in response to, and within, degraded environments as a major training objective.

Doing so will more realistically test and train commanders and their staffs to operate in such environments and adapt in the face of dynamic and challenging environments. This should become a more "doable do" as well if the recommendation to develop more realistic training environments is implemented.

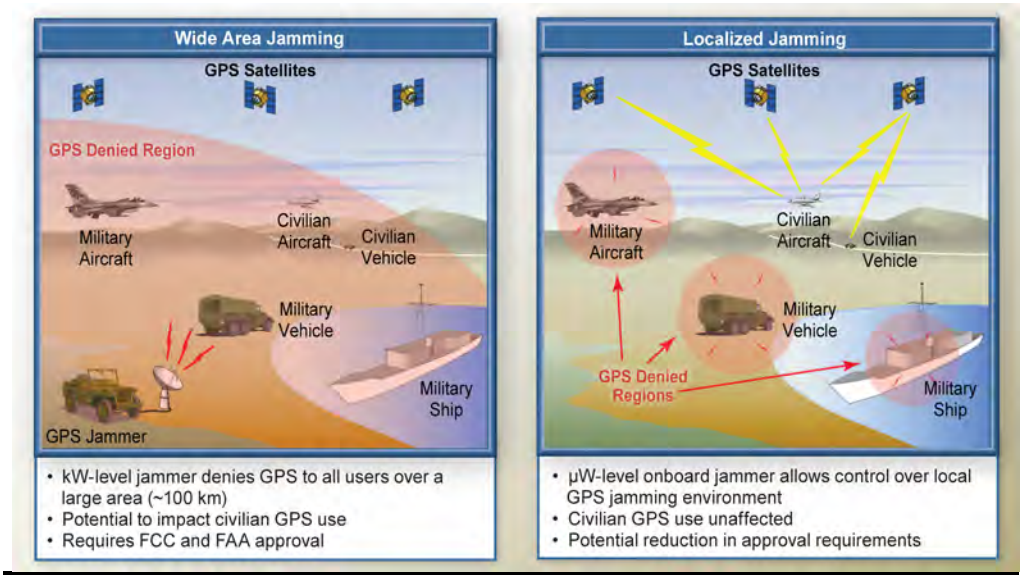


Figure 5-3. Training in a GPS Denied Environment

Implementation Action. Combatant commands, Services, and DOD civilian leadership conduct limited table top exercises with the objective of practicing their process(es) for developing courses of action in response to degraded and unexpected scenarios.

The DSB recognizes both the need to train senior leadership and their supporting staffs to operate in degraded environments and the time constraints that limit senior leaders' ability to participate in routine exercises. An alternative approach is for senior leadership to engage in a range of less time-consuming exercise options from table top scenarios to multi-person games supported by simulation, with the objective of gaining a better understanding of the resources available to support decision-making under a range of future, but unknown conditions. Selection could be made based on the amount of time a senior leadership team might have available or as part of a building block approach, whereby successive exercises become increasingly complex with an ever larger training audience. To further focus these training events, we recommend that they be based on the Defense Planning Scenarios.

Red Teaming and Blue Teaming

Red teaming and blue teaming have been used by business enterprises over the years to identify weaknesses and corrective actions for products and processes. But these terms are used differently within segments of the DOD enterprise, so it is useful to define what is meant by red teaming and blue teaming in this report.

In red teaming a team of trained, educated, and practiced team members provides an independent capability to continuously explore weaknesses and/or vulnerabilities associated with DOD plans, operations, concepts, organizations, and capabilities. Typically, these teams employ subject matter experts who perform analyses based upon a characterization of the physical behavior or capabilities of the activity in question (*i.e.*, a physics-based analysis) or based upon the processes that govern the operation of the activity (*e.g.*, a concept of operation or TTP-based analysis). In either case, the team typically embodies expertise of both adversary, or "red," capabilities and U.S., or "blue," characteristics.

Such red teaming is perhaps more appropriately referred to as red/blue teaming, to emphasize that knowledge of both "red" and "blue" capabilities is required. An essential product of red teaming is a characterization of potential "blue" weaknesses or vulnerabilities, but very often the red team also provides suggestions for remediation of the identified problem areas. Once the red team identifies a set of vulnerabilities, a blue team is engaged to assess the seriousness of the weaknesses, as well as potential solutions to the problem areas. Analogous to the red team, blue teaming requires subject matter experts with various levels of understanding of "red" capabilities.

In contrast, there are situations in which a red team is established in order to assess vulnerabilities for programs of various types (*e.g.*, acquisition programs). In these situations, the threats typically involve programmatic hurdles, such as cost and/or schedule risk, the use of immature technology, or the lack of domestic suppliers for critical components. In these cases, the output of the red team is often a definition of programmatic challenges, provided through appropriate management channels to the program, which then responds in a manner similar to the blue team discussed above. In the remainder of this chapter, these types of activities are referred to as programmatic red teaming.

Red teaming has been a recognized need for many years. It has been recommended by several groups, including the DSB, but effective red teaming has proven to be difficult, especially above the tactical level.[49] Perhaps the most obvious reasons that it has not been more widely implemented are the perceived or real threat to the programs supported, lack of top-level support, and organizational distance from the decision-making process.

Nonetheless, red teaming is especially important in today's security environment. Nimble adversaries with access to the global technology market are very difficult targets for intelligence so that anticipation and corresponding readiness depends more heavily on intellect rather than factual observations. Properly implemented red teams can fill this gap as surrogate adversaries by challenging "blue" assumptions and offering alternative "blue" approaches.

The Services' tactical training programs demonstrate the impact of effective red teaming. Typically characterized by world-class "red" forces and by open and

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49. See *Defense Science Board Task Force on the Role and Status of DOD Red Teaming Activities*, September 2003. http://www.acq.osd.mil/dsb/reports/ADA430100.pdf Accessed August 12, 2010; and *Defense Science Board 2010 Summer Study on Capability Surprise—Volume I Main Report*, September 2009. http://www.acq.osd.mil/dsb/reports/ADA506396.pdf Accessed August 6, 2010.

honest critiques, these red teams are also widely recognized as providing a significant capability edge to U.S. forces. The model examples of successful red teams include:

- U.S. Navy SSBN Security Program Red Team
- Air Force Air Vehicle Survivability Program
- Opposition Forces, Red Teams and Training Centers
- B-2 Bomber Red Team
- Nuclear Weapons Black Hat Program
- AMRAAM Red Team
- MX Red Team

The first two of these red teams have been chartered for multiple decades, are focused on survivability of strategic assets, and are comprehensive in scope and scale. They are both funded on the order of $50 million per year. Consequently, they serve as fitting examples to measure comparable efforts.

The Navy's ballistic missile submarine (SSBN) survivability effort was chartered in 1970 "to develop all relevant technologies on a continuing basis to ensure the long-term survivability of the present Fleet Ballistic Missile force as well as providing the technological base for any future sea-based systems."[50] Johns Hopkins University Applied Physics Laboratory was chosen as the lead laboratory. Its work was based on first-principles physics, end-to-end model development, extensive at-sea measurements, and quantifying the limits of detectability. The products of the SSBN program included comprehensive signature characterization, authoritative threat assessment, validated signature and detectability models, and operational guidance, as well as countermeasure concepts and prototypes such as vulnerability monitoring systems and tactical decision aids.

The Air Force Air Vehicle Survivability effort, with MIT Lincoln Laboratory as the lead laboratory, is similar in many respects and stresses:

- **Independence**. To challenge blue plans and assumptions at tactical and strategic levels.
- **Connectivity**. To work with war fighters, intelligence, technology base, and senior leadership.
- **Excellence**. Technical experience in systems analysis and testing.
- **Integrity**. Disciplined approach focused on fundamental issues.

50. Dr. John Foster, Director, Defense Research and Engineering, 1970.

The explicit mission of this Air Force Red Team is to provide independent assessments, backed by testing, to senior DOD and Air Force decision-makers. The team also evaluates current and potential future threats to U.S. Air Force operations, identifying and highlighting critical gaps that may be exploited by current and future threats, and facilitating and setting goals for U.S. technology development to close identified gaps.

The common characteristics of these successful red team efforts include:

- connectivity to the highest levels of the organizations involved
- threat and scenario analysis and synthesis
- comprehensive analytic, experimental, and operational elements
- strong systems cell with strong individuals
- complete independence from the programs involved

Red teams in the general case can be created in many domains and may function as surrogate adversaries, devil's advocates, or as general advisory boards. In addition, red teams may have varying degrees of knowledge of "blue" capabilities (from none to full), may be anticipatory with respect to future adversary abilities, and may identify vulnerabilities as well as possible mitigation techniques.

Approaches to Red Teaming and Blue Teaming

To be effective, a red/blue team must be integrated into a systematic decision-making process at an early stage. The basic function of a red/blue team is to assess inputs from a variety of sources and, based on that assessment, to recommend actions to leadership. The team should also assess the impact of any action taken, or conversely, the lack of impact of action not taken. These activities are ongoing (Figure 5-4).

To effectively challenge assumptions, red/blue teams must be sensitive to inputs from a variety of sources. Clearly, they must monitor inputs from the intelligence community and experiences from ongoing operations. They should also be receptive to inputs from unexpected or non-traditional sources. Finally, in view of the talent and creativity of the members of the team, important insights will come from within the team.

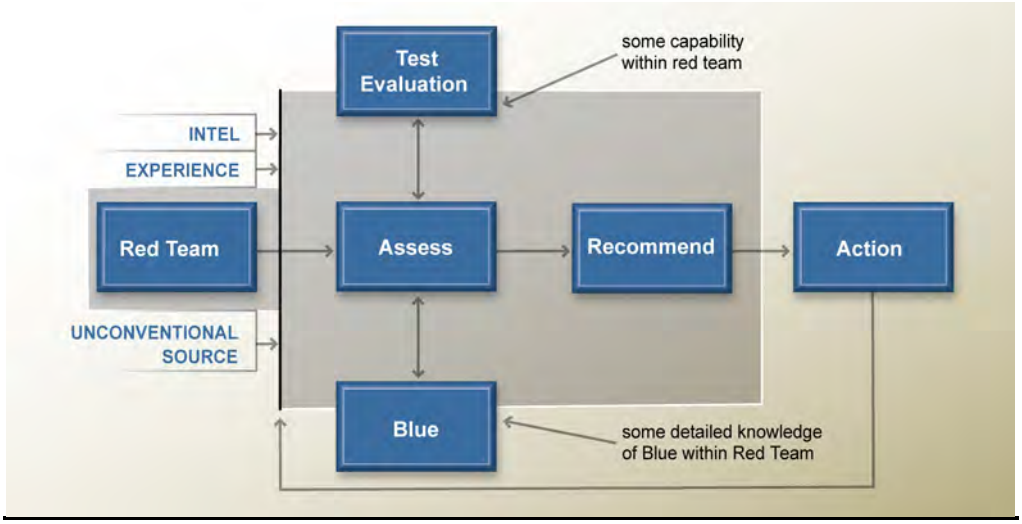

Figure 5-4. Red Team Function and Organization

Having identified a potential risk, the red/blue team will assess its potential impact and consider possible mitigation. To do this they must have significant knowledge of both existing and planned "blue" capability. Therefore, the team must have members who are very familiar with "blue" capability but report directly to the red/blue team to maintain the independence of the team. Finally, since in making their assessments the red/blue team must have access to computer modeling tools or to laboratory test capacity, arrangements for this access must be in place on an ongoing basis. The Air Force Air Vehicle Survivability program is an example of a red/blue team that has "organic" laboratory assets for experimentation.

The recommendations of the red/blue team should reflect both the ingenuity of the team in challenging assumptions and their depth of expertise in making rigorous assessments. Successful red teams such as the Air Force Air Vehicle Survivability Program and the U.S. Navy's SSBN Red Team have, over time, been successful in maintaining both independence from and a good working relationship with "the program."

The relationship between the "red" and "blue" sides can be complex and varies depending on the mission. As noted above, in order to be effective, a red team must have considerable organizational independence from the "blue" organization. On the other hand the red team and the "blue" organization share the same intellectual space and it is difficult to draw a distinct boundary between them. In other words "red" and "blue" inhabit the same phenomenological world, face the same threat environment, and are bound by the same resource constraints. Considerable interaction between

"red" and "blue" is expected during the course of concept development and this interaction may be best acknowledged with the term "red and blue teaming."

Organizationally, the interaction between "red" and "blue" can be manifested in a variety of ways depending upon the mission. For example, in an operational red team such as an opposing force, the "blue" side is represented virtually within the red team. In other cases, such as The Air Force Vehicle Survivability Program, there are members of the team who develop "blue" counter-countermeasure concepts and tactics.

Figure 5-5 depicts the flow in cases where concepts are developed in response to newly identified threats. Here, the red team utilizes available intelligence to identify known enemy threats. In addition, given an understanding of the capabilities of the adversary, a set of potential threats is also defined. A threat assessment is then performed based upon concepts of operations/TTPs and the physical limitations of the system that characterizes the likelihood of the threat and its predicted effectiveness against "blue" forces. A critical output of the red teaming activity is the identification of high-likelihood, high-impact threats. In operational exercises red teams may actually carry out that activity.

The blue team is tasked with assessing the impact of the high-priority threats, including those identified by the red team, and, if appropriate, exploring the development of countermeasures. Countermeasure exploration may take several forms: analytical, quick demonstrations, and system-level prototypes. Periodically, the red and blue teams issue a vulnerability assessment along with recommendations for remediation.

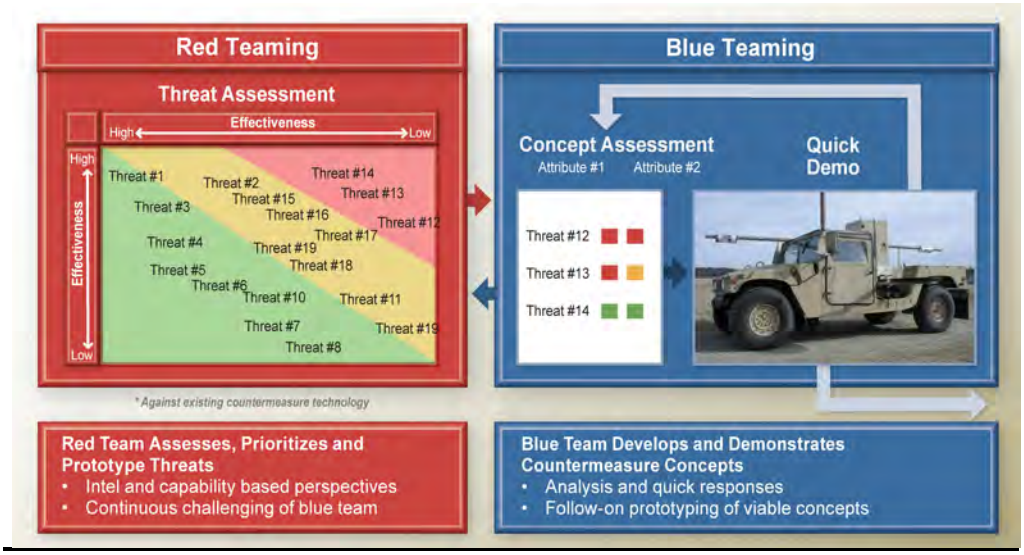

Figure 5-5. Red and Blue Teaming

Cyber-Systems Red Teaming

The importance of red teaming in dealing with the cyber threat has been discussed in many previous DSB reports. We believe that it is appropriate to use a red team as discussed above. Given the widespread exposure to the cyber threat, DOD could consider establishing numerous red teams—or, alternatively, a consolidated standing cyber red team that serves the entire community.

To evaluate these alternate approaches we considered the attributes of effective red teams as discussed in the 2003 DSB study on red teams.[51] The study enumerated a number of attributes of effective red teaming, several of which are quite useful for this evaluation: 1) enterprise culture (tolerance of disruptive thinking), 2) top cover, 3) robust interaction between the red and blue teams, and 4) carefully selected staff.

We believe that a consolidated approach is more likely to result in the appropriate level of top cover and enterprise level protection of an organization that produces potentially disruptive recommendations. Second, a consolidated team is more likely to result in assembling a "critical mass" of talent. Finally a cyber-systems red team should have access to knowledge of "offensive" techniques, and people with deep knowledge of these techniques are not widely distributed.

Red and Blue Teaming Recommendations

Implementation Action: Establish red and blue teaming within the combatant commands and Services to investigate current and future threats and drive the formulation of adaptive mitigation strategies.

Based upon the demonstrated successes of prior and ongoing red teams, the DOD needs to utilize red teaming much more broadly than is the current practice. In addition to increasing adaptability of U.S. forces at the tactical, operational, and strategic levels, red teaming activities have the potential to provide senior decision-makers with early feedback regarding the effectiveness of investment strategies, improving the cost effectiveness of strategic decisions. In order for red teaming to become more pervasive, both the combatant commands and the

51. *Defense Science Board Task Force Report on The Role and Status of DOD Red Teaming Activities,* September 2003. http://www.acq.osd.mil/dsb/reports/ADA430100.pdf.

Services must assume joint responsibility, and incorporate these practices into planning for operational exercises and the development of TTPs, and integrate red teaming into training activities.

Implementation Action. Establish cyber-systems red and blue teams within U.S. Cyber Command to identify vulnerabilities and potential remediation across the DOD, and factor those conditions into future exercises and training.

By tasking this responsibility to U.S. Cyber Command, as opposed to distributing responsibility broadly across the DOD, the critical cyber-systems threats can be identified, prioritized, and addressed in a coordinated manner throughout the enterprise. Nevertheless, this red teaming would require coordination between the National Security Agency, Defense Intelligence Agency, U.S. Cyber Command, and U.S. Space Command. As discussed previously, the military's use of cyber-systems has become truly ubiquitous. Computer resources and networks, operating at both the unclassified and classified levels, are employed in virtually every aspect of the DOD enterprise. There is evidence that indicates many significant vulnerabilities of the DOD cyber-system, and as the threat continues to mature these vulnerabilities will continue to grow.

Cyber and Space

The United States depends on a number of critical operational support systems across the range of military operations. Of these, space and cyber systems are particularly vulnerable to potential disruptions (Figure 5-6). For this reason, the summer study explored in detail the attributes of these systems, their vulnerability to internal and external degradation, and steps to mitigate their vulnerabilities or the impact of potential degradation.

Cyber

Cyber elements—computing systems and networking—have become pervasive in the U.S. military. Embedded systems bring unprecedented levels of flexibility and performance to modern weapons and other combat systems; information systems support logistics as well as virtually all other aspects of managing the U.S. armed services. But dependence on cyber elements comes with a risk: the failure of a

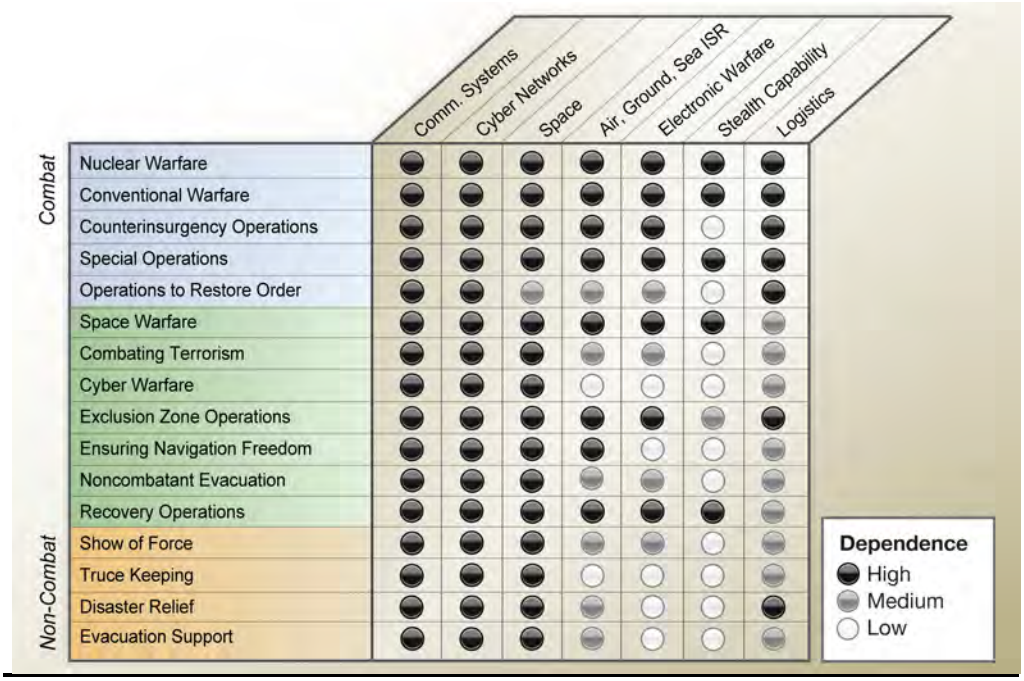

Figure 5-6. Critical Operational Dependencies on Communications, Cyber, and Space Systems

computing system or network to perform as expected can now threaten the success of military operations. Information infrastructure is thus both our military's greatest enabler and its Achilles heel.

This is not the first time that war fighters have embraced new technologies and, in so doing, have accepted risks that inevitably accompany this increased dependence. However, never before has a single technology so permeated our nation's military operations. Nor has one society become wed to a technology that could be so easily attacked from afar. Moreover, attackers can hide their identities, which make reprisals impossible to undertake and renders deterrence problematic as a defense. In addition, the barrier to entry for attackers of cyber elements is quite low.

Because it would be unwise for the U.S. military to divorce itself from using cyber elements, the Department needs to contemplate changes to the design and use of these systems. This approach would then enable peacetime and military operations to adapt to degradations in performance or functionality of the cyber elements on which they depend. Those changes are the subject of this section.

Cyber elements implement three different kinds of functionality. First, cyber elements establish the networks through which forces communicate and distribute information. For example, with the Joint Tactical Information Distribution System (JTIDS) system, a cockpit display in a fighter jet shows a pilot the locations of targets as well as details of other aircraft in the theater. This information is being relayed to the fighter from a net-manager (typically the Airborne Warning and Control System (AWACS)) that receives data from sensors and other fighters. Second, cyber elements provide the means to store information and retrieve it as needed. Storage densities are extremely high, allowing cheap and compact devices to store an enormous amount of information. The stored information might be transient in nature, such as recent images of a battlefield, or it might be long-term, such as local maps or field-maintenance manuals for some piece of equipment. Third, cyber elements have a capacity to perform computation, which makes it possible to transform information into new forms, whether it be parameters for directing a platform (such as steering a weapon), charts to inform a commander about changes in the current situation, or fusing images of the same locale taken in different modalities (*e.g.*, electro-optical, radar, or infrared). Command and control applications combine communication, storage, and computation.

Different techniques are available to the adversary to mask degradations of networking, storage, and computation. Thus, when contemplating mitigations for degraded cyber elements, knowing how those cyber elements are being used can inform how their environment might be designed to tolerate degradation.

Degradation and its Consequences

Failures, attacks, and human (user or operator) errors all can lead to cyber elements failing to deliver some expected service or delivering some unexpected (and undesirable) service. A compromised cyber-element might exfiltrate secret information to an attacker. It might become unresponsive because needed resources have been co-opted by an attack. It might execute corrupt programs and destroy data or compute incorrect answers (jeopardizing any military operation that uses these outputs). The absence of service is easy to detect; corrupted data is not easy to detect, though certain designs facilitate such detection.

The effects of a degraded cyber-element depend on how that element is being used in some larger system. Moreover, there is a large space of possible operating modes for a degraded cyber-element. Perhaps the simplest case is when the degraded element simply stops rendering a service and this outage is immediately

detectable. Many military systems are already designed to cope with a degraded operation that occurs in response to reduced functionality or capacity, because the culture is experienced with the use of assets that must be scheduled and rationed according to externally imposed priorities. And, as noted above, the most problematic forms of degraded operation to mitigate occur when the cyber-element appears to be functioning correctly but its outputs are misleading.

Defense against cyber-attacks is known to be a difficult problem. It is well studied, so it was not a focus of the current effort.[52,53,54,55] Nevertheless, progress in the design and development of secure cyber elements would translate directly into cyber elements that, in the presence of attacks, are less likely to be forced to operate in a degraded mode.

Some of the challenge arises from issues that cannot be controlled (Figure 5-7). This state of affairs is then exacerbated by various degradations that could be controlled but are not. Among the items that cannot be controlled is the rapidly changing nature of the threat. As a result, defenders must defend all places at all times, against all possible attacks (including those not known about by the defender) while attackers need only find one vulnerability. Attackers also have the luxury of inventing and testing new attacks in private as well as selecting the place and time of attack at their convenience. Moreover, new attacks can often be relatively cheap while new defenses are expensive to develop and deploy. Also, defenders have significant investments in their systems, whereas attackers have minimal sunk costs and thus can be quite agile. Finally, deterrence is difficult to meaningfully achieve because attribution of attacks is often not possible. In particular, attacks might be launched from machines that an attacker only temporarily controls but somebody else (possibly in another country) owns. And when an attack crosses international boundaries, the law and policies of other countries apply, creating further complications for attribution.

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52. System Security Study Committee, *et. al*. *Computers at Risk: Safe Computing in the Information Age*. Washington DC, National Academies Press, 1991. http://books.nap.edu/catalog.php?record_id=1581 Accessed August 6, 2010.
53. Committee on Information Systems Trustworthiness. *Trust in Cyberspace*. Ed. Fred B. Schneider. Washington, DC, National Academies Press, 1999. http://www.nap.edu/openbook.php?record_id=6161# Accessed on August 6, 2010.
54. Committee on Improving Cybersecurity Research in the United States. *Toward a Safer and More Secure Cyberspace,* Ed. Seymour E. Goodman and Herbert S. Lin. Washington, DC, National Academies Press, 2007. http://books.nap.edu/catalog.php?record_id=11925 Accessed August 6, 2010.
55. President's Information Technology Advisory Committee. *Cyber Security: A Crisis of Prioritization,* Arlington: National Coordination Office for Information Technology Research and Development, February 2005. http://www.nitrd.gov/pitac/reports/20050301_cybersecurity/cybersecurity.pdf Accessed August 6, 2010.

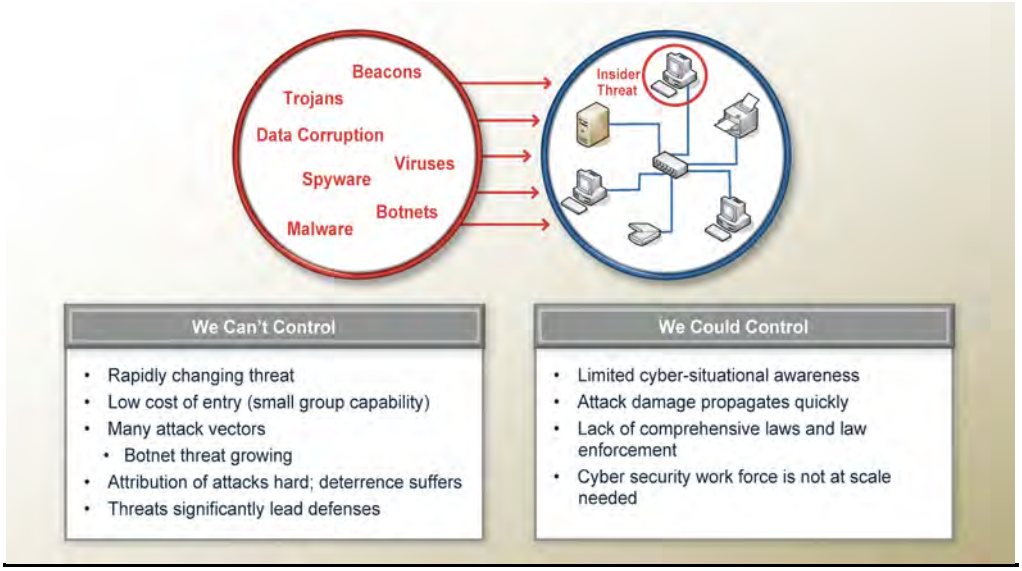

Figure 5-7. Cyber Attacks Pose Significant Challenges

Some cyber-security problems are the result of degradations that could be controlled but, for one reason or another are not. Systems are designed and built in ways that leave them vulnerable to attack and that facilitate propagation of attacks from one machine to another. This is partly attributed to a lack of focus on security as a priority in the marketplace (many systems used in defense applications are designed for the mass market) and a difficulty in measuring the value it delivers. That the workforce lacks expertise in cyber-security does not help. Limited support for situational awareness in cyber elements means that it is difficult to know whether and when a component has been compromised, so it can be difficult for operations staff to change the configuration in order to repel an attacker.

Prevention of attacks involves more than eliminating software vulnerabilities and more than educating human beings about safe practices that help defend against phishing and other forms of spoofing. Attacks on cyber elements can be planted in either hardware or software by subverting the supply chain and installing a Trojan horse for activation at a subsequent time. But attacks also can be as simple as destroying a physical asset, such as destroying a tower carrying fibers in use by a network, or recruiting an insider who is willing to subvert the system. In short, the cyber-security problem is one of enormous proportion and is more than a technical problem.

Avoiding Degradation: Replication and Diversity

Commanders have long known that the dependence on an individual piece of equipment can be reduced through redundancy. Instead of deploying a single piece of equipment, they deploy several. If one is not functioning, another can take its place. In addition, physically separating the pieces of equipment decreases the chances that a single kinetic attack will simultaneously incapacitate multiple instances. Physical separation increases the costs an attacker must incur in order to obliterate all of the physical instances.

The same basic approach works for cyber elements. Replication and physical separation of hardware components decreases the chances that a physical event (*e.g.*, a kinetic attack or even a cosmic ray event) could cause multiple cyber elements to fail. However, attacks that arrive electronically (through messages or other system inputs) are just as easily sent to all instances of the cyber-element as to one. Replication alone is not sufficient for defending against attacks that exploit software vulnerabilities. However, the same attack is less likely to be effective at compromising all instances of a cyber-element if the different instances are diverse and, therefore, differ in their implementation details. Thus, diverse cyber elements force an attacker to engineer and launch a separate attack for each separate instance, analogous to the way separate kinetic attacks must be launched in order to cause physically separated instances to fail.

The desired diversity may already exist for certain cyber elements. For example, different implementations of processors having the same instruction set architecture are manufactured by both Advanced Micro Devices and Intel; multiple distinct communications paths often are present at a command post in a theater (*e.g.*, wire-line Internet, cell-phone WiFi, and satellite-based Milstar); and several web browsers today enjoy common usage on PC-based platforms.

But finding diverse instances of most software is unlikely. The cost of procuring separate, diverse instances of a program or software system is likely to be prohibitive. Fortunately, that is not necessary because tools already exist to artificially create diversity in software. From a single instance of a program or system (in source code or in binary code), these obfuscators rearrange the locations of variables, the entry-points for system services, and/or the exact sequences of instructions in ways that do not change what the program does but do change how the program does it. An obfuscator will, with some probability, change which implementation vulnerabilities are present, and that in turn changes whether an attack will succeed against any given particular instance. Microsoft's Windows® Vista® operating system and its successors

are shipped with a mechanism to randomly rearrange the location of variables, for example. And the fear of a software monoculture in the Internet has prompted some to advocate that all COTS software components be deployed with some sort of obfuscator, so that a single piece of malware is less likely to compromise all sites on the Internet.

More generally, redundancy is useful when building almost any system that must adapt to adverse circumstances and degrade gracefully. When the component or system is not able to provide an expected service, the presence of redundancy allows some alternate to be invoked. This, however, presupposes situational awareness to detect that a component is not delivering a required service. Although networks are constructed in a way that typically provides that situational awareness, most other cyber elements today are not. Additional internal interfaces and more expressive error indicators typically would have to be included in a cyber-element, so that it (whether it is an application or an entire stand-alone hardware/software system) can perform an analysis and report on the nature of degraded operation it is providing.

Degraded cyber elements can produce outputs that are misleading, and these are particularly difficult to handle. Redundancy is also useful here. If there are "n" redundant sources of information (*e.g.*, one primary with "n" redundant/back-up systems) then the existence of up to n-1 erroneous outputs can be detected because at least two of the systems agree, implying that their output is correct. However, redundancy does have a cost. One must balance the benefits of detecting erroneous outputs against additional costs.

The chances that a cyber-element must operate in a degraded mode can be reduced by eliminating its dependence on other components. For example, critical information is best identified and cached locally; and proxy copies of external services can also sometimes be run locally. Having local copies eliminates dependence on network connections. More generally, it is a good practice for networked computers that are deployed in a theater to be configured in a way that allows the network to be segmented, since this eliminates a dependency.

Also, combatant commanders should be empowered and have the controls to isolate those parts of a network that have been assigned to them for combat use. This would eliminate a dependency on the larger network (which might itself be subject to other attacks or conflicting resource demands), which in turn lead to a more robust capability.

Key Findings With Regard to Cyber Systems

1. *Almost all military operations, and the conduct of the DOD enterprise, depend on cyber systems, and therefore are vulnerable to cyber-related degradation.*
2. *Limited capabilities exist for maintaining cyber-system situational awareness.*

   It is usual to be able to determine some aspects of network status—in particular, to know whether a link between two points is operational, or to know the current message-traffic flow rate (bandwidth) across that link. Networks routinely maintain status history that facilitates analyzing traffic loads over time and link outages. Similarly, an operating system that manages the resources of a platform (that is, processors, memory, and communication ports) often will record resource usage measures over time. But, it is unusual that an operating system would report what those resources are being used to do. And, it is even rarer for an application to report whether cyber resources it requires are available to that application and, if not, what is happening. There is also often no avenue for the operator to even pose such questions.
3. *Limited mitigations are available to a commander for restoring effective operation when cyber-systems are degraded.*

   Not only is the situational awareness for cyber elements absent, but few tools exist that enable a commander to take action in response to changes in that situation. There are tools that permit controlled, real-time reconfiguration of a network, and there are tools for the allocation of individual compute platform resources. Priorities governing the use of these resources can be dictated. By and large, extant tools directly change parameters of the hardware or of the closely related hardware control software for the network and the operating system. Applications are executed one step removed from the hardware—the operating system is an intermediary. Since there are few applications that report problems, there are few tools at the application level that can be used to take restorative action and little operating system support.
4. *Current operational exercises offer limited realism for operating with degraded cyber systems.*

   Most current exercises do not explore detection of cyber degradation. Instead, "white card" inputs are used to announce a shift to degraded cyber conditions. Moreover, the supporting cyber system in these exercises has not changed; the users are asked to make believe that it has. Also, most current exercises do not explore operating in the spectrum of degraded cyber-operation: they

tend to be "cyber-on/cyber-off." As a result, participants do not acquire an experience base that they can apply in the field when degraded operation of cyber elements occurs. The Department also misses out on an opportunity to gain assurance that U.S. systems indeed would work in their intended environments.

5. *Red and blue teaming is not used broadly today to drive the scenarios for operational testing and exercises.*

   Cyber red teams are typically not sustained over the years, as needed to build maturity and expertise. Yet, cyber attacks generally are increasing in number and sophistication, and the reliance of military operations increasingly relies on cyber support. Blue teams are not being used against these red teams. The advantages of red and blue teaming are discussed in the previous section.

Implementation Actions:

1. **In future acquisitions, the Services require that cyber-systems:**

- Provide cyber-situational awareness to users and commanders.
- Allow operation in degraded mode to be imposed, both for field management of cyber assets and for exercises.
- Provide tools both for awareness and for user reconfiguration to impose intended degradation; include today's tools for sensing and manipulating the hardware and a few aspects of the operating system.

  Tools that communicate to the user in terms of the abstractions that applications create should be developed and employed. Most attacks seen today disrupt the performance of the underlying resources—communications, memory, and processors. But applications should be able to evaluate their own behavior to determine whether some aspect of it might be corrupted, and then report that corruption to users (if only upon request).
- Ensure that applications are capable of being directed to operate in degraded mode, perhaps with reduced communication or processing resources, or perhaps operating from cached information at the site, rather than external feeds, which may be suspected of being corrupt. This functionality would allow exercises to be conducted using field-capable equipment. It also might be useful for defense, since it provides a (albeit crude) way to deprive an attacker of access to resources.

2. U.S. Cyber Command (collaborating as needed) provide a set of cyber scenarios for incorporation into planning for operations and operational testing. These should go beyond "white cards" and span the spectrum of cyber-degradations that include: partial or full communication outage, data corruption or data outage, and processing outage or processing limitations due to resource exhaustion.

3. Combatant commanders put in place detailed back-up plans and mitigation approaches for reducing cyber security risk. Once the tools discussed in Implementation Action 1 are put in place, the combatant commanders should have more options for planning and operation.

4. Combatant commands and Services direct that exercises designed to train and evaluate the ability to adapt to degraded operations be conducted with field equipment. Simulations are valuable for exploring attacks and developing defenses, but training typically should be conducted on go-to-war equipment because simulations necessitate too many simplifications, especially in the cyber realm. It could be helpful to create special networks that facilitate interconnection of the go-to-war equipment for training purposes.

5. USD (AT&L) and Services determine a basis on which to devise cyber security key performance parameters (KPPs) tailored to specific acquisition programs. Currently, systems for which cyber-security is deemed important do not have KPPs to capture desired security attributes. It is not immediately obvious what measure of performance should be required, and how a system might be tested to determine whether that KPP is achieved. The challenge is made more difficult because the set of attacks that the system should be able to withstand almost certainly will change as the adversary adapts. We recommend that USD (AT&L) and the Services determine the basis on which to devise KPPs tailored to specific programs.

Space

Space systems have proven invaluable in providing war fighters with detailed information about characteristics and activity in a geographical region. They also can bring communications services into locales where the use of terrestrial radio or stringing cable is infeasible.

But space systems are invariably controlled by cyber-systems. These cyber elements appear on-board and at base stations. They control scheduling of processing, sensor allocation to various tasks, and allocate up-link and down-link

bandwidth to better serve users. Cyber elements are also used to coordinate collections of satellites to handle reconfiguration should there be an outage. This means that the operation of a satellite could degrade if the controlling cyber-system is not functioning properly. The increasing dependence on space systems implies a corresponding reliance on cyber-systems. And any credible study of space system degraded operation must acknowledge that dependence. That dependence noted, space systems can succumb to other kinds of failures and attacks, as well.

The survivability of space systems is a complex issue with significant challenges. Some of the challenges are similar to those faced for cyber systems, and, as noted above, fall into two broad categories (Figure 5-8):

1. Those that cannot be controlled, such as details of the threat.
2. Those that could be controlled, such as the development of countermeasures and counter-countermeasures.

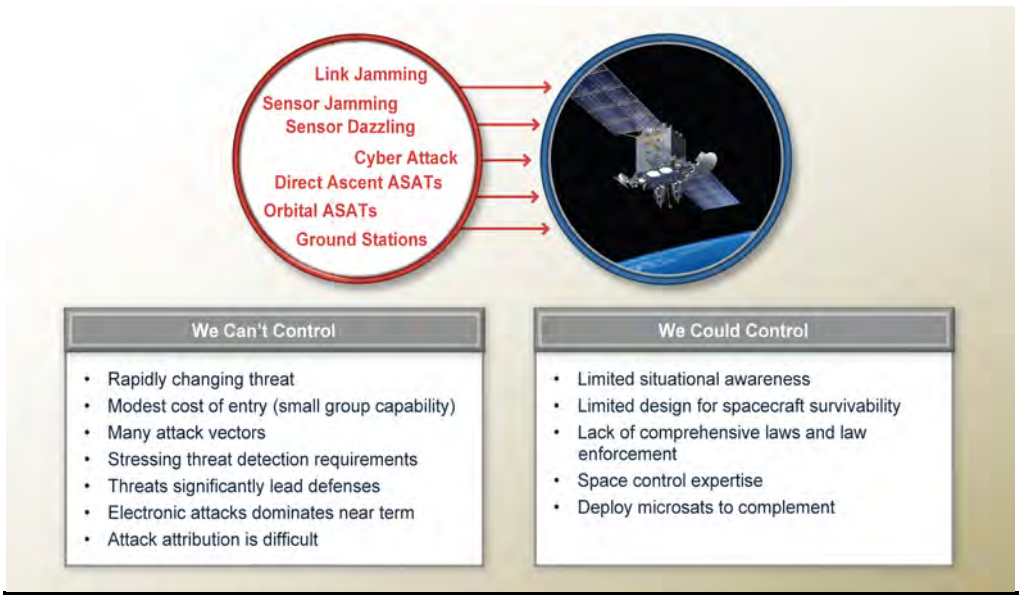

Figure 5-8. Space Survivability: Significant Challenges

Space systems are vulnerable to a wide range of threats, including foreign space object surveillance and identification, reversible denial of service and disruption attacks, and non-reversible kinetic and non-kinetic attacks. To further complicate the problem, some of the current threats have small signatures and stress the detection capabilities of current space situational awareness systems. While nations who are currently engaged in space typically have the capacity to engage or

otherwise interfere with space systems, many of the threats have a modest cost of entry. As such, even small states may have the capability to implement some of the lower-level reversible and non-reversible attack vectors. In fact, some electronic attack approaches are easy enough to implement that they may become the attack vector of choice for small states. In all cases the threat may change rapidly and stress the capabilities of U.S. detection systems and countermeasure approaches.

The countermeasure component of space survivability is also very complex. Although the United States has been developing new space situational awareness systems, enhancements are still needed for advanced threats. Improvements in spacecraft survivability need to be incorporated into new space systems while improved detection and defensive systems, along with a supporting legal construct, need to be developed to assist in the deterrence of attacks.

Space Survivability Findings

The summer study reviewed several space-related survivability programs, including the Air Force Space Survivability Red Team and other national-level studies on space system vulnerabilities and protection. Several findings emerged as a part of the review.

1. *Most military operations are significantly dependent on space operations.*

   Most military systems-associated operations are dependent at some level on our national space capabilities. This dependency can create significant advantage, as well as significant disadvantage; back-up plans and mitigation approaches need to be in place for enabling continued operations under degraded conditions. Space situational awareness is critical to mitigating and operating through attacks.

2. *Space assets require cyber elements and consequently are vulnerable to cyber attack.*

   Cyber networks are an integral part of any space system and, as such, space assets are vulnerable to cyber attack, as noted earlier in this chapter. However, complicating cyber issues associated with space systems are the unique security, culture, and legacy hardware and software systems that make detecting and protecting these space assets that much more difficult.

3. *Space situation awareness is limited.*

   As with cyber systems, our ability to maintain space situational awareness (SSA) over our space assets is limited thereby limiting the ability of commanders to recognize the need and adapt to degraded conditions. If attacks are not recognized, planned back-up and mitigation approaches may not be put into place in a timely way and dependent systems may degrade significantly.

4. *Our nation's ability to mitigate degraded space systems is limited.*

   Considering the remote environment of space and the inability to typically change out hardware on flying space assets, our current ability to mitigate degraded space systems, once noted, is limited and based on original design features. Future space systems need to be designed with built in situational awareness and mitigation measures and designed to accommodate dynamic reconfigurations in response to emerging threats.

5. *Degraded operations are inadequately portrayed in space exercises.*

   Operational exercises should be useful for identifying potential vulnerabilities and mitigation approaches; however, current operational exercises offer very limited realism and sophistication when it comes to demonstrating operational capabilities with degraded space systems.

6. *Space survivability red/blue teaming has limited involvement in operational testing and exercises.*

   To assist in the identification of potential vulnerabilities and mitigation approaches, robust space survivability red/blue teaming could be better leveraged when testing new space systems and in developing exercises with degraded space systems. Such red/blue teaming could be used to better anticipate future threats and to explore mitigation approaches.

Several approaches could be used to improve space survivability (Figure 5-9). The goal of this section is to provide an overview of some of the potential survivability approaches, not a comprehensive list. A key component of space survivability is redundancy in space sensing, communication, and precision navigation and timing systems. This redundancy may include systems that are pre-positioned in space, as well as systems that provide some capability through land-, sea-, and air-based systems. For example, some back-up sensing might be part of air-based systems that provide a smaller, but useful regional surveillance. Terrestrial communication links may be effective backup for cases when space communications links are down.

Another component of space survivability is the enhanced survivability of space platforms and data link information. These protection techniques often need to be designed into space architectures early in their development phase. The techniques may involve both hardware and software improvements to the system. Space architectures that enable hardware and software improvements through open system interfaces and block upgrades are inherently more adaptable and survivable against many of the advanced threats.

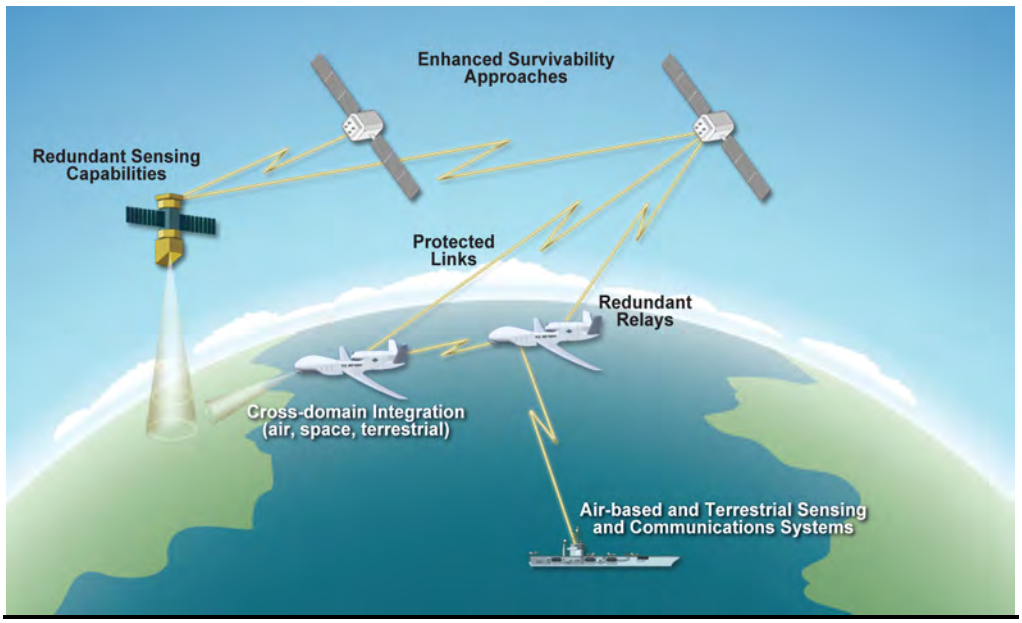

Figure 5-9. Improved Survivability for Future Space Systems

Implementation Actions:

1. **DOD and intelligence community continue to refine a comprehensive strategy for space survivability and to address operational limitations.** This comprehensive strategy should include approaches for improving the survivability of satellites, as well as protection of data links and ground support systems. Of particular importance for this strategy is the growing overlap of space systems with our nation's cyber systems. The vulnerability of cyber network infrastructure within space systems may represent the weakest link in the survivability of space systems.

2. Combatant commanders put in place detailed back-up plans and mitigation approaches for reducing space survivability risk. These back-up plans and mitigation approaches may include the stronger integration of ground-, sea-, and air-based systems into the space architecture. Clear plans need to be in place to allow the use of these systems if space capabilities degrade.

3. U.S. Strategic Command provide a set of degraded space scenarios for incorporation into planning for operations and for operational exercises. Many of the Service and combatant command operational exercise planners are unclear on the specific details of space threat scenarios that drive degraded operations. Strategic Command should provide scenarios to assist operational exercise planning. These scenarios should allow planners to increase the degraded conditions as needed to stress the exercise participants.

4. Strategic Command improve the U.S. space situational awareness capability. Improved space situational awareness is a key component of improving adaptability under degraded conditions. SSA has improved over the past several years, but more is needed to add capability for advanced threats. SSA information needs to be better shared across the protected data networks to improve the awareness of space system status.

5. USD (AT&L) and Services determine a basis on which to devise cyber and space security KPPs for acquisition programs. Space survivability KPPs are needed to drive the development of future systems. These KPPs may specify the need for enhanced space situational awareness through improved sensing and information distribution. The KPPs might also specify that space systems incorporate the ability to switch into degraded modes for training and operational exercises.

Individual Adaptability

This study examined individual adaptability in the context of how the military services develop and train, primarily in the context of degraded operations at the tactical level. The results are reported in the remainder of this chapter. A more general discussion of the state of research in testing and training for adaptability is included in Chapter 6.

Adaptive Training and Testing

The individual is the key to adaptability—either as a single combatant or as a member of an organizational unit (team, squad, command staff, etc.). Yet a widely agreed upon description of "adaptability" is elusive. In the context of military operations, people generally agree that "adaptability" implies the ability to cope with unplanned events or environments, but researchers have determined that the general concept of adaptability is multidimensional.[56]

The I-ADAPT model, adopted by the Army's Asymmetric Warfare Group (AWG), illustrates the point.[57] As shown in Figure 5-10, the AWG parses adaptability attributes into core, enabling, and supporting categories. In addition, the research group that developed the I-ADAPT model examined test populations consisting of a variety of ranks and occupations (mostly military) and determined that the eight adaptability attributes shown do not correlate well with each other. The researchers further determined that the specific nature of adaptability needs vary significantly with job classification.

Figure 5-10. The I-ADAPT Model: One Basis for Tailored Training

From this and other findings,[58] the DSB observes that screening individuals for "adaptability" requires a multifaceted assessment matched to roles of individuals in their organizations. More work is needed to determine more precise definitions and improved screening methods.[59] However, models such as I-ADAPT can serve very

56. Burns, William R. Jr. and Waldo D. Freeman. *Developing an Adaptability Training Strategy and Policy for the DOD: Interim Report,* Institute for Defense Analysis, October 2008.
57. Pulakos, Elaine, D., *et. al*. "Adaptability in the Workplace: Development of a Taxonomy of Adaptive Performance," *Journal of Applied Psychology*, 2000, vol. 85, no. 4, pp 612–624.
58. Hancock and Szalma (ed.). *Performance Under Stress*, Ashgate Publishing Ltd., 2008, 210–213. The Army's Readiness Assessment and Monitoring System, for example, has been developed from a wide range of studies and analyses.
59. Hancock and Szalma. The Services already support some work in this area, but its application beyond specialty assignments is not widespread.

useful purposes: (1) to ensure that the full spectrum of adaptability is addressed in training; and (2) given that each individual will exhibit stronger and weaker adaptability traits, teams should be formed with complementary strengths to maximize team adaptability.

Training for Adaptability

It has been axiomatic in all militaries for eons to "train as you fight and fight as you train." Thus, broad exposure to those elements during training that may mimic the unfamiliar or unexpected during battle is critical. Clausewitz wrote, "It is immensely important that no soldier, whatever his rank, should wait for war to expose him to those aspects of active service that amaze and confuse him when he first comes across them. If he has met them even once before, they will begin to be familiar to him."[60] Long-standing service experience shows that appropriate training improves an individual's ability to cope with unexpected, stressing, degraded, or even chaotic military situations; in particular, the field of stress exposure training seeks to create training environments that are realistic enough to introduce the trainee to a range of possible stressors he/she is likely to encounter in the war fighting situation they are preparing to enter.[61] The three principles of stress training are:

1. Enhance familiarity with the task environment, to include the likely stressors and their effects.
2. Impart high performance skills, relevant to the particular stress environment.
3. Practice skills and build confidence, but in a manner that allows gradual exposure to the stressful environment in order to build the trainee's confidence.

These principles are embodied in the representation by the AWG, shown in Figure 5-11, as the basis for individualized adaptive training.

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60. Clausewitz, Carl von. *On War*, Princeton University Press, 1976 edition, 122.
61. Hancock and Szalma, Chapter 14. See also J. A. Cannon-Bowers and E. Salas (ed.). "Making Decision under Stress: Implications for Individual and Team Training," *American Psychological Association*, 1998.

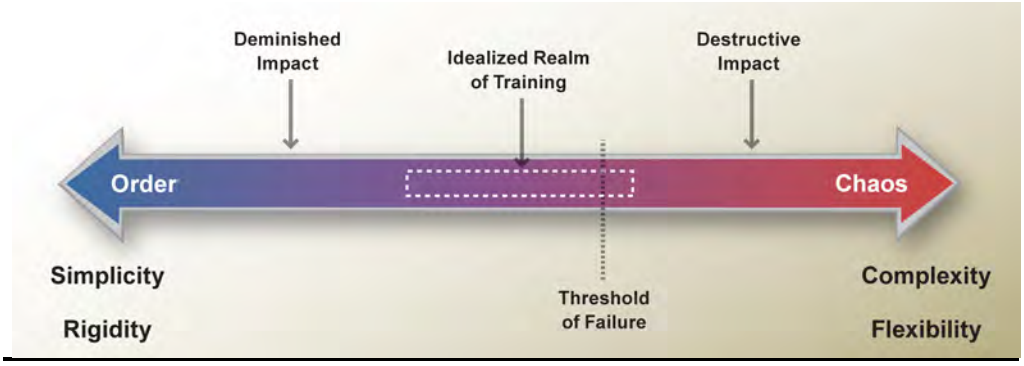

Figure 5-11. Adaptive Training and Exercises: Balancing Risk and Performance

Briefings from the Marine Corps, SOCOM, the Air Force, and Army Training Command (described in the previous section), while not intentionally highlighting these principles, indicated that training regimes are based on a general syllabus that calls for initial situations that are well ordered, progressing to increased disorder as the course proceeds. At the start, training improves basic skills, such as combat tactics, weapons proficiency, and situational awareness and assessment. This foundation enables clearing the mind to concentrate on adapting to the unanticipated. As the trainee moves toward more and more chaos, he or she eventually reaches failure.

Training is designed to progress to the failure point gradually, based on the hypothesis that "stress testing," in ever more complex scenarios, induces learning and improves ability to cope with increasingly complex, disordered situations, *i.e.*, to become more "adaptable."[62] We note that degrading the environment in many curricula by "white carding" (*i.e.*, announcing to a trainee specific equipment is not available for use) is a valuable training technique, but does little to build skills to identify when critical information has been corrupted (*e.g.*, gradual degradation).

The AWG claimed that the Army observed that roughly 25 percent of individuals appeared to be inherently adaptable and thrived on chaos, while another ~25 percent could not be trained to adapt well in almost any situation. The AWG are seeking to develop and improve the adaptability traits of the middle 50 percent through a more tailored approach to individual training. The DSB believes that if indeed these observations are correct, then testing for adaptability could and should influence job and team assignments.

62. N. Friedland and G. Keinan, "Training Effective Performance in Stressful Situations: Three Approaches and Implications for Combat Training," *Military Psychology*, no.4, 1992, 157–175.

One of the key questions asked in the stress exposure training community has been the effectiveness of the testing experience when the trainee subsequently experiences environments or events outside of the test environment. While the research is not extensive, it does indicate a positive correlation between stress exposure testing and the ability of the individual to cope effectively with unanticipated events in the war fighting environment.[63,64]

Much more, however, remains to be learned about how to improve effectiveness and specificity of training to enhance inherent adaptability. The DSB discovered that the industrial psychology literature base provides some insight into adaptability of individuals; published research on group adaptability is not as rich at providing similar perceptiveness for groups. While additional research is ongoing, the DSB concludes that training and exercises to improve individual adaptability should continue and improve as new knowledge of adaptability assessment and learning becomes available. The focus needs to be broadened, as well, from individuals to teams across a range of operating unit sizes. Training and exercises for larger military units to improve adaptability is an essential element of military culture. Unit exercises are critical to achieving organizational effectiveness. Despite a long history, however, the effectiveness of adaptability training at the operational level is, as yet, only anecdotal. Much less is known about adaptability of groups than for individuals and small units.

As discussed in the previous section on operational exercises, the paucity of experience with operational-level adaptability stems, at least in part, from the practical difficulties of including complex degradations in large-scale exercises. A "low hanging fruit" opportunity for development of adaptability skills is to inject the topic of adaptability as an element in all facets of military education, from basic training to capstone courses. This should apply to both enlisted and officer education. Adaptability need not be limited to distinct curricula. Regular small group tabletop exercises conducted by commanders with their staffs to reinforce adaptability skills gained in formal educational programs can be effective in applying schoolhouse learning to on-the-job applications.

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63. M. L. Gick and K. J. Holyoak, "The Cognitive Basis of Knowledge Transfer," *Transfer of Training: Contemporary Research and Applications*, Academic Press, 1987, 9–46.
64. R. A. Schmidt and R. A. Bjork, "New Conceptualization of Practice: Common Principles in Three Paradigms Suggest New Concepts for Training," *Psychology Science*, no. 3(4), 1992, 207–217.

Implementation Actions:

1. Service chiefs and civilian leadership emphasize adaptability, within the boundaries of commander's intent, as a desirable professional trait.

Several steps are important for this to happen:

- Each Service should articulate general and/or mission-specific adaptability traits.
- Supervising officials should include evaluation of adaptability traits in training and fitness report.
- Field units should routinely provide feedback to training commands on the adequacy of current training to enhance adaptability.
- The Service chiefs should direct all levels of military education (enlisted, noncommissioned officer, and officer) to develop and insert modules on adaptability into their curricula where they are not already present.
- Services civilian leadership should mimic their military counterparts and insist on adaptability screening and education for the civilian workforce as appropriate to positions.

2. Service chiefs and the Under Secretary of Defense for Personnel and Readiness direct personnel organizations, working with the Service and Department laboratories, to develop testing techniques and instruments that assess individual aptitude for adaptability. Results of testing should be used both for assignment and training actions, and for creating teams whose members possess complementary adaptability traits to match their roles.

3. Service chiefs direct training commands to create adaptive training modules that can be applied both generally and selectively to enhance individual and team adaptability capabilities.

4. Service and DOD labs establish long-term monitoring and assessment programs to evaluate the efficacy of testing tools and the impact of adaptive training as a basis for continuous improvement in training and education for adaptability. The training commands should in turn enlist the support of the research community to help in designing curriculum and content.

Human Performance in Degraded Environments

Throughout this chapter, the focus has been on needed changes in various elements of the enterprise to adapt to changing and, in particular, degraded situations. There is universal agreement that the most adaptable part of the system is the human, and hence the interest expressed in the previous section on adaptive training to improve the adaptability of the force. Equally important is the corollary issue—namely, how well one might understand and measure the threshold of failure in which external stressors overtake the ability of the individual to adapt.

The previous section introduced a concept of training for adaptability in which the key feature is pushing the individual or team to the threshold of failure, or possibly just beyond, in order to develop adaptability skills; *i.e.*, "constructive" human failure. And with repetition of the training scenario, the individual's threshold of failure often shifts to higher stress or complexity levels as he/she learns from prior experience.[65,66]

A positive feature of the training environment is that it allows intervention, and therefore recovery and learning when the threshold of failure is breached. Destructive or catastrophic outcomes can almost always be avoided, and indeed the training outcomes are generally positive. The war fighting environment is, however, not nearly as forgiving. Intervention before the threshold of failure or breakdown is important, but the variability in human behavior can make this very difficult, if not impossible. Today's best, and often only, tools are keenly observant commanders and/or teammates who detect behaviors that deviate from the norm for the individual. Can more be done? The DSB's assessment: "maybe, but it is critically important to try."

Human Performance Under Stress

The stress of combat is as old as war itself. Thucydides' *History of the Peloponnesian Wars* is a compelling depiction of the trauma of war and its aftermath. What is new is that, for the first time in our military's history, U.S. forces are fighting a long duration war with a professional military where Service members are exposed to repeat lengthy combat tours of at least twelve months with

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65. This result is not unique to the military training environment. A number of studies confirm that experience tends to improve individual adaptability. See for example: Janis, I.L. "Problems Related to the Control of Fear in Combat," *The American Soldier – Combat and Its Aftermath*, Princeton University Press, 1949, 223.
66. S. J. Lorenzet, *et al*. "Benefiting from Mistakes: The Impact of Guided Errors on Learning Performance and Self-Efficacy," *Human Resource Development Quarterly*, no. 16(3), 2005, 301–322.

little time to "reset" between deployments. The effects of repeated and prolonged exposure to combat is no longer solely a veterans' care issue, but has now for the past decade been of critical concern to the operational forces as well. The U.S. military is, in short, in new and uncertain terrain.

Human performance under stress is a huge area of research among the behavioral, social, and neuro scientific communities. This study had neither the time nor expertise to do the topic justice, but was able—through discussion and feedback from several professionals in the field—to come to the following observations.

There are many correlative studies, largely of an observational nature, but many with sound statistical analysis of the data collected, that infer important cause and effect relationships pertinent to the resilience or adaptability of individuals under stressful conditions. Some examples of interest to war fighting conditions include:

Survival and experience. The strong correlation between personal survival and experience is intuitive, but also well documented.[67] It has been observed that stress levels in experienced individuals compared to novices are not less, but the abilities to assess, decide, and act earlier are better. In other words, the human "OODA [observe, orient, decide, act] loop" improves with experience.

Cognitive performance and sleep. Degraded cognitive performance is strongly correlated with poor sleep quality and/or sleeping disorders[68]—problems common in combat zones. Prolonged cognitive degradation increases the susceptibility to breakdown from an acute high stress event(s)[69]—many instances of which occur in a combat zone. Given also the strong linkage between sleeping disorders and Post Traumatic Stress Disorder (PTSD),[70] a growing number of investigators are beginning to suspect that sleep deprivation is a principal contributor to the alarming growth of depression and PTSD among deployed and returning war fighters.[71]

Team decision-making and perception of stress. The absolute level of workload, ambiguity of the information available, time pressures, and other external stressors

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67. W. D. Fenz and G. B. Jones, "The Effect of Uncertainty on Mastery of Stress: A Case Study," *Psychophysiology*, no.9(6), 1972, 615–619.
68. N. L. Miller, *et al*. "Fatigues and its Effect on Performance in Military Environments," *Performance Under Stress*, Ashgate Publishing Ltd., 2008, 231–249.
69. J. A. Caldwell, "Fatigue in Aviation," *Travel Medicine and Infectious Disease*, no. 3, 2005, 83–96.
70. Thomas Mellman, *et. al*. "REM Sleep and the Early Development of Posttraumatic Stress Disorder." *The American Journal of Psychiatry*, no. 159, October 2002, 1696-1701.
71. B. Krakow, *et al*. "Clinical Sleep Disorder Profiles in a Large Sample of Trauma Survivors: An Interdisciplinary View of Posttraumatic Sleep Disturbance," *Sleep and Hypnosis*, no.9 (1), 2007. http://www.sleepandhypnosis.org/article.asp?id=197 Accessed August 6, 2010.

may not be the principal driver of stress within a team in comparison with the internal characteristics related to skill levels of team members, degree of common information among them, and how well responsibilities are distributed within the team. The interplay of the individual's neurobiology and psycho-social makeup is enormously complicated. The science, while extensive, is immature in its understanding of the interplay of all the factors.[72,73]

Neurobiological factors. Regions of the brain, controlling different functions important to stress resilience, rely on exquisite modulation of uptake or suppression of region specific biochemicals, depending on the degree of stress and return to normality being experienced.[74] The principal message for our purposes is that an individual's "brain chemistry" provides a number of potential correlative markers for stress resilience. This might—but not without much more research—form the basis for pre-symptomatic monitoring of the potential for breakdown or depression.

Psycho-social factors. There is a strong association between stress resilience and five basic psycho-social factors, and linkages between each factor with neural mechanisms tied to specific neurochemicals.[75] Those factors are:

- Positive emotions, including optimism and humor.
- Cognitive flexibility, including a positive explanatory style that tends to view problems as temporary, solvable, and of limited impact; cognitive reappraisal that finds positive meaning in an adverse event; and acceptance, as opposed to resignation.
- Spirituality, including religious or other belief systems that provide a framework for understanding adversity and making sense of tragedy; and creating opportunities for altruism.
- Social support, which influences physical as well as mental health; and role models or mentors who can provide the positive patterns, knowledge, skills, etc., to be imitated.

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72. T. Kontogiannis, "Stress and Operator Decision Making in Coping with Emergencies," *International Journal of Human-Computer Studies*, no. 45, 1996, 75–104.
73. D. Serfaty, *et al. Team Adaptation to Stress in Decision Making and Coordination with Implication for CIC Team Training*, Alphatech Report No TR-564, Vol. 1&2, Burlington, MA, 1993.
74. For a summary of the neurochemistry associated with acute stress, see: Stephen M. Southwick, *et al*. "The Psychobiology of Depression and Resilience to Stress: Implications for Prevention and Treatment." *Annual Review of Clinical Psychology*, no.1, 2005, 255–291.
75. Stephen M. Southwick, *et al.* 2005.

- Active coping style that focuses on approaching the problem and solving it (vs. passive coping typical of depressives characterized by avoidance and emotion); and includes exercise and training where many studies have identified the positive neurological responses of the brain.

The sampling above should convince the reader of the complexity of understanding human stress response. It is a good example of a "wicked problem" for which there is no closed form solution.[76] Across a wide range of research results, the summer study observed a tendency to postulate and affirm/refute numerous single-factor, cause-effect relationships. However, as a wicked problem, this area can be better understood and managed through a systems approach in which the many factors in play are systematically collected and characterized, and their multi-dimensional interactions addressed.

Improve Understanding of and Mitigate Human Performance Degradation

With the alarming growth in suicides, incidents of PTSD, and diagnoses of depression being experienced in the U.S. military,[77] the DSB believes that the Department needs to place priority on both improving the ability of the military to adapt in theater, and expanding abilities to monitor and intervene prior to serious degradation of individual performance. This terse characterization of human performance under stress is intended to motivate action, and we recommend the following actions to get started.

"*Systems Approach*." At a foundational level for each of the following recommendations, the approach should be multi-disciplinary among the scientific, systems, medical, personnel, training, and operational communities. While not a recommendation *per se*, the DSB believes a more integrated approach that takes advantage of a broader set of perspectives and approaches is needed. Such is the nature of wicked problems in order to be successfully managed.

To better understand and mitigate human performance degradation, the DSB offers the following actions.

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76. *Report of the Defense Science Board 2010 Summer Study on Capability Surprise*—Volume I Main Report, Appendix A, September 2009; http://www.acq.osd.mil/dsb/reports/ADA506396.pdf Accessed August 6, 2010.
77. H. Vogt, "Military Keeping Traumatized Soldiers in Combat Zones," *Associated Press*, 2010; http://www.msnbc.msn.com/id/3034566/ns/health-mental_health Accessed August 6, 2010.

Implementation Action: Director, Defense Research and Engineering (DDR&E) lead a **major Defense Advanced Research Projects Agency (DARPA) and cross-Service R&D program** that:

- Undertakes experimentation and measurements to identify a few pre-symptomatic physiological and neurochemical markers that might be readily monitored in battlefield environments.
- Develops rugged, miniaturized rapid diagnostics based on the marker set identified for battalion (or lower) level field use.
- Addresses sleep deprivation impacts systematically, and seeks non-pharmacological ways to induce "quality" sleep in time-constrained environments.
- Monitors and correlates the short- and long-term impact of individual diagnostic measures on performance and mental well-being while in-theater and when back home.

In spite of the large body of work on performance under stress, there remain many unanswered questions, poorly understood cause-effect relationships, and little data taken over extended periods of time, especially in the context of the deployment cycles that are currently the norm. More and different research and development is needed.

Implementation Action: The Services continue to make every effort to **maintain cohesion of personnel assignments** at the small unit level in order to build the support and innate observational systems that could greatly enable early intervention where needed.

In addition, actions in the field should be consistent with doctrine and supporting research; *e.g.,*

- Shorten deployments (~6 months).[78]

78. Mental Health Advisory Team (MHAT) VI Operation Enduring Freedom. *Executive Summary, Risk Factors*. Page 2, November 6, 2009. http://www.armymedicine.army.mil/reports/mhat/mhat_vi/MHAT_VI-OEF_EXSUM.pdf Accessed August 11, 2010.

- Establish field behavioral health care detachments at the battalion level and below.[79]
- Increase awareness among team leaders at every level of combat stress and behavioral health.[80]
- Expand existing behavioral health programs to develop comprehensive pre-, during-, and post-deployment psychological resiliency and combat stress mitigation programs.[81]

The above specifics come directly from Army medical reports based on examination of its own data. As the military continues to push beyond historic experience in this "long war" with lengthy and repeated deployments, the impact of combat stress can only get worse unless more aggressive actions are taken.

The DSB supports the work that has been done and is ongoing in the areas of behavioral health research, acute combat stress, and psychological resiliency research, awareness, and training. More research is needed, however, to understand the basic underlying factors that affect human psychological performance under stress. Additional steps can also be taken today to mitigate the impact of prolonged, repeat exposure to combat stress. A large body of data collected from combat operations in Iraq and Afghanistan provides empirical evidence to support actionable recommendations that can be implemented immediately.

These implementation actions are driven not only by a moral imperative to provide the best possible care for Service members. The long-term health of the all-volunteer force also depends upon the continued psychological readiness of career non-commissioned officers and officers. The future readiness of the military depends on mitigating the well-documented negative impact of repeat combat deployments and implementing a comprehensive pre-, during-, and post-deployment program of behavioral health care for Service members.

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79. MHAT VI Operation Iraqi Freedom. *Executive Summary, Recommendations*. Pages 3-4, May 8, 2009. http://www.armymedicine.army.mil/reports/mhat/mhat_vi/MHAT_VI OIF_EXSUM.pdf Accessed on August 11, 2010.
80. Nancy A. Youssef, "Army suicides: Poor leadership, not repeat deployments blamed." *McClatchy Newspapers*. http://www.mcclatchydc.com/2010/07/29/98364/army-suicides-poor-leadership.html Accessed August 16, 2010.
81. MHAT VI Operation Iraqi Freedom. *Executive Summary, Recommendations*. Page 4, May 8, 2009. http://www.armymedicine.army.mil/reports/mhat/mhat_vi/MHAT_VI-OIF_EXSUM.pdf Accessed on August 11, 2010.

Summary of Key Recommendations

Prepare for degraded operations by institutionalizing the use of realistic training and exercises and red/blue teaming to prepare for uncertain conditions.

For training and exercises:

- Services' training commands develop approaches for realistically emulating degraded environments.
- Combatant commanders direct that future operational level exercises incorporate operating in response to, and within, degraded environments as a major training objective.
- Combatant commands, Services, and DOD civilian leadership conduct limited table top exercises with the objective of practicing their process(es) for developing courses of action in response to degraded and unexpected scenarios.

For red and blue teaming:

- Establish red and blue teaming within the combatant commands and Services to investigate current and future threats and drive the formulation of adaptive mitigation strategies.
- Establish cyber-systems red and blue teams within U.S. Cyber Command to identify vulnerabilities and potential remediation across the DOD, and factor those conditions into future exercises and training.

For cyber:

- **In future acquisitions, the Services require that cyber-systems:**
  - Provide cyber-situational awareness to users and commanders.
  - Allow operation in degraded mode to be imposed, both for field management of cyber assets and for exercises.
  - Provide tools both for awareness and for user reconfiguration to impose intended degradation, include today's tools for sensing and manipulating the hardware and a few aspects of the operating system.

    Tools that communicate to the user in terms of the abstractions that applications create should be developed and employed. Most attacks seen today disrupt the performance of the underlying resources—communications, memory and processors. But, applications should be able to evaluate their own behavior to determine whether some aspect of

it might be corrupted, and then report that corruption to users (if only upon request).

  - Ensure that applications should be capable of being directed to operate in degraded mode, perhaps with reduced communication or processing resources, or perhaps operating from cached information at the site, rather than external feeds, which may be suspected of being corrupt. This functionality would allow exercises to be conducted using field-capable equipment. It also might be useful for defense, since it provides a (albeit crude) way to deprive an attacker of access to resources.

- **U.S. Cyber Command (collaborating as needed) provide a set of cyber scenarios for incorporation into planning for operations and operational testing.** These should go beyond "white cards" and span the spectrum of cyber-degradations that include: partial or full communication outage, data corruption or data outage, processing outage or processing limitations due to resource exhaustion.
- **Combatant commanders put in place detailed back-up plans and mitigation approaches for reducing cyber security risk.** Once the tools discussed in Implementation Action 1 are put in place, the combatant commanders should have more options for planning and operation.
- **Combatant commands and Services direct that exercises designed to train and evaluate the ability to adapt to degraded operations should be conducted with field equipment.** Simulations are valuable for exploring attacks and developing defenses, but training typically should be conducted on go-to-war equipment because simulations necessitate too many simplifications, especially in the cyber realm. It could be helpful to create special networks that facilitate interconnection of the go-to-war equipment for training purposes.
- **USD (AT&L) and Services determine a basis on which to devise cyber security KPPs tailored to specific acquisition programs.** Currently, systems for which cyber-security is deemed important do not have KPPs to capture desired security attributes. It is not immediately obvious what measure of performance should be required, and how a system might be tested to determine whether that KPP is achieved. The challenge is made more difficult because the set of attacks that the system should be able to withstand almost certainly will change as the adversary adapts. We recommend that USD (AT&L) and the Services determine the basis on which to devise KPPs tailored to specific programs.

For space survivability:

- **DOD and intelligence community continue to refine a comprehensive strategy for space survivability and to address operational limitations.** This comprehensive strategy should include approaches for improving the survivability of satellites, as well as protection of data links and ground support systems. Of particular importance for this strategy is the growing overlap of space systems with our nation's cyber systems. The vulnerability of cyber network infrastructure within our space systems may represent the weakest link in the survivability of space systems.
- **Combatant commanders put in place detailed back-up plans and mitigation approaches for reducing space survivability risk.** These back-up plans and mitigation approaches may include the stronger integration of ground-, sea-, and air-based systems into the space architecture. Clear plans need to be in place to allow the use of these systems if space capabilities degrade.
- **U.S. Strategic Command provide a set of degraded space scenarios for incorporation into planning for operations and for operational exercises.** Many of the Service and combatant command operational exercise planners are unclear on the specific details of space threat scenarios that drive degraded operations. Strategic should provide scenarios to assist operational exercise planning. These scenarios should allow planners to increase the degraded conditions as needed to stress the exercise participants.
- **U.S. Strategic Command improve the U.S. space situational awareness capability.** Improved space situational awareness is a key component of improving adaptability under degraded conditions. SSA has improved over the past several years, but more is needed to add capability for advanced threats. SSA information needs to be better shared across the protected data networks to improve the awareness of space system status.
- **USD (AT&L) and Services determine a basis on which to devise cyber and space security KPPs for acquisition programs.** Space survivability KPPs are needed to drive the development of future systems. These KPPs may specify the need for enhanced space situational awareness through improved sensing and information distribution. The KPPs might also specify that space systems incorporate the ability to switch into degraded modes for training and operational exercises.

For individual adaptability:

- **Service chiefs and civilian leadership emphasize adaptability, within the boundaries of commander's intent, as a desirable professional trait.**

  Several steps are important for this to happen:

  - Each Service should articulate general and/or mission-specific adaptability traits.
  - Supervising officials should include evaluation of adaptability traits in training and fitness report.
  - Field units should routinely provide feedback to training commands on the adequacy of current training to enhance adaptability.
  - The Service chiefs should direct all levels of military education (enlisted, noncommissioned officer, and officer) to develop and insert modules on adaptability into their curricula where they are not already present.
  - Services civilian leadership should mimic their military counterparts and insist on adaptability screening and education for the civilian workforce as appropriate to positions.
- **Service chiefs and the Under Secretary of Defense for Personnel and Readiness direct personnel organizations, working with the Service and Department laboratories, to develop testing techniques and instruments that assess individual aptitude for adaptability.** Results of testing should be used both for assignment and training actions, and for creating teams whose members possess complementary adaptability traits to match their roles.
- **Service chiefs direct training commands to create adaptive training modules that can be applied both generally and selectively to enhance individual and team adaptability capabilities.**
- **Service and DOD labs establish long-term monitoring and assessment programs to evaluate the efficacy of testing tools and the impact of adaptive training as a basis for continuous improvement in training and education for adaptability.** The training commands should in turn enlist the support of the research community to help in designing curriculum and content.

To improve understanding of and mitigate human performance degradation:

- DDR&E lead a **major DARPA and cross-Service R&D program** that:
  - Undertakes experimentation and measurements to identify a few pre-symptomatic physiological and neurochemical markers that might be readily monitored in battlefield environments.
  - Develops rugged, miniaturized rapid diagnostics based on the marker set identified for battalion (or lower) level field use.
  - Addresses sleep deprivation impacts systematically and seeks non-pharmacological ways to induce "quality" sleep in time constrained environments.
  - Monitors and correlates the short- and long-term impact of individual diagnostic measures on performance and mental well-being while in-theater and when back home.
- The Services continue to make every effort to **maintain cohesion of personnel assignments** at the small unit level in order to build the support and innate observational systems that could greatly enable early intervention where needed.

Chapter 6. Enhance Adaptability of the Workforce

The Department is faced with an unpredictable and changing environment, which will be characterized by frequent deployments across the spectrum of military operations. In this future, personnel and organizations that can cope with unforeseen circumstances will have an advantage. Future operations are also likely to require personnel with skills that are not ordinarily resident in active duty forces or in the permanent cadre of DOD civilians. Examples drawn from recent experience in Iraq and Afghanistan include individuals with backgrounds in foreign languages, agriculture, local government, and banking, where individuals with these skills have been found through *ad hoc* searches within guard and reserve forces. Other examples of such needed skills beyond the Iraq and Afghanistan campaigns include spectrum management and familiarity with digital electronics design tools.

Because of the importance of personnel in adaptable organizations, the summer study considered personnel policies that could facilitate adaptability in the Department of Defense across several different dimensions including:

- Promoting availability of personnel with needed skills, including skills from the larger civil society, that may be required in future operations.
- Identifying individuals who are more adaptable in the sense that they may be better able to make effective decisions when faced with unforeseen circumstances.
- Training individuals to be more adaptable (assuming this is possible).
- Ensuring that organizations can cope with unforeseen circumstances.

Accessing Personnel with Needed Skills

Active Force

In an uncertain world, DOD simply cannot afford to maintain an active duty force with all the skills that might be necessary to operate successfully in a wide range of possible future environments. Therefore, just as there is a need for the intelligence community to guide requirements in the acquisition community, DOD needs a strategy tied to an assessment of the future security environment to determine those skills that are most needed in the active force, coupled with a hedging strategy for acquiring other skills from the whole of civil society. The wars in Iraq and Afghanistan

should provide a rich source for making an initial study of these issues. The summer study has recommended that the intelligence community begin the process of collecting information about other likely trouble spots and the types of responses that DOD might have to make in those areas (Chapter 4). These studies would provide a basis for adjustment of an initial personnel strategy.

RECOMMENDATION: ASSESSING AND ACQUIRING NEEDED SKILLS

The Under Secretary of Defense for Personnel and Readiness (USD (P&R)), in coordination with each military department, develop within 6 months an initial personnel strategy. This strategy should determine the types of skills that have been and will be required for ongoing and future operations, and the methods to be used to acquire those skills.

We also recommend that an immediate effort be made to identify useful skills held by active duty members that are not today identified in established personnel systems. Initiatives such as the Army Green Pages and the Navy Assignment Incentive Pay (AIP) program are being used to better match the skills (and interests) in portions of the active duty force with deployment requirements. The Army Green Pages effort is similar to social networking programs such as Facebook, or resume inventory systems such as USAJOBS, that allow an individual to create a resume or "page" discussing his or her background that can then be searched for relevant skills, including by key words.

This type of system could provide a useful first step to implementing a skills inventory. The further benefit of a skills inventory used in this way is that it capitalizes on volunteerism—the individual has a chance to affect positively his or her assignment, while the institution maintains the final say on the best use of personnel. Presumably, this approach leads to a better fit between personnel and assignments, with improved motivation and career retention, in the best spirit of the all-volunteer force.

Implementation Action: Each Service assistant secretary for manpower provide a plan for creating a skills inventory within the active force with the goal of reporting to the USD (P&R) within 6 months and that the USD (P&R) then work with the Services to propagate those systems that seem most promising.

Reserve Components

The reserve components are likely to be an even richer source of civilian skills and an effort should be made to collect the data needed to systematically search the reserve ranks for persons with the gamut of skills that may be required by future operations.

Implementation Action: The Assistant Secretary of Defense for Reserve Affairs (ASD (RA)) create within the next 2 years an all-service National Guard and reserve database to capture civilian skills and experience.[82]

It has also become apparent that an important aspect of fielding adaptable equipment will be forward-deployed technical teams with the skills needed to modify equipment in the field or at least to direct the modifications necessary to meet changed threats (discussed in Chapter 3). In the past, most technical expertise of this type has been provided by contractor personnel. Many concerns have been raised about how contractors are being used in deployed locations, and some have suggested that it would be useful to have skilled technicians in uniform as an alternative to or supplement for contractor forces. Similar suggestions have been made concerning translators or other personnel with regional subject matter expertise.

Implementation Action: ASD (RA) undertake an effort to tabulate key skill shortfalls identified by combatant commanders over the last three years (*e.g*. agricultural specialist, city managers, water system engineers) and work with other principal staff assistants to establish requirements for future needs (for example, for persons skilled with digital electronics tools who might modify or redesign software in the field). Establish goals for recruitment.

The ASD (RA) should establish goals for recruitment to the reserve component individuals with the needed diversity of skills, including, if required, establishing new reserve detachments to facilitate their recruitment and training. Given the types of non-traditional skills required, it may be appropriate to waive standards (*e.g*., physical fitness) that might otherwise apply to these units.

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82. This database should also include the Individual Ready Reserve.

Exploit the Skills of Military Retirees

Military retirees provide an additional cadre of individuals who possess both military and civilian skills that might be useful in future contingencies but, again, the problem is to identify those retirees who possess the skills needed for a specific operation.

Implementation Action: The ASD (RA) create, within one year, a database of retirees and their military and civilian skills, for potential future call-up use, and to maintain that database with periodic updates.

Establish incentives for the use of retirees[83] and propose legislation, as needed, for inclusion in the FY 2012 President's budget request.

Civilian Personnel

The Department has taken a number of steps to recruit civilians for temporary government employment as it finds a need for unique skills. These programs include the National Language Service Corps (NLSC) and the Highly Qualified Expert (HQE) authority.

The NLSC program seeks to create a register of individuals with unique language skills who could be available on short notice to provide translation and related services to DOD. This program is in addition to language skills training programs currently being conducted by all of the military services. Under the NLSC program, volunteers with expertise in languages important to the United States serve as on-call federal employees to provide their expertise to local, state, and federal agencies. This civilian corps can be used whenever and wherever language skills are needed, including emergency relief operations or in times of international or domestic crisis. Currently the NLSC is in its pilot stage and is funded by the National Security Education Program run by DOD. Once NLSC is fully implemented, it is expected to include 30,000 members with expertise in over 150 languages. The Department currently enrolls 219 persons under this program as shown in Table 6-1.

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83. Use of military retirees has been resisted over the years. For example, Section 531 of the Fiscal Year 2011 House Defense Authorization Bill would require the Secretary of Defense to provide a plan "to eliminate the use of recalled retirees."

Table 6-1. National Language Service Corps

Component	Total Employed
Army	72
Navy	50
Air Force	5
DOD Agency/Activity	92
Grand Total	219

The HQE program focuses on a different need: to bring highly skilled, highly paid workers into the federal government. It provides for employment of up to 5,000 experts for up to five years at salaries more competitive with private industry. The HQE program has a purpose broadly similar to the Intergovernmental Personnel Act (IPA), except that the latter is restricted to individuals drawn from academia and qualified non-profit institutions. The Department currently employs only 228 people[84] under the HQE program (Table 6-2).

Table 6-2. Highly Qualified Expert Authority

Component	Total Employed
Army	90
Navy	19
Air Force	31
DOD Agency/Activity	88
Grand Total	228

The Department has also recognized a need to have DOD civilians deploy, as civilians, to support military forces. The Civilian Expeditionary Workforce program is intended to identify and inventory employees who are willing to deploy so that their skills can be accessed as required. The concept was first used in early 2007 to provide manning for provincial reconstruction teams. This effort revealed that it was difficult to obtain civilians for deployment because they would not be replaced at their home station jobs, and supervisors were reluctant to lose their services while on leave for deployment. In an effort to resolve this and other problems, the USD (P&R) issued a policy memorandum in early 2008, setting out the Department's

84. DARPA has an additional 18 employees hired under similar but separate legal authorities.

strong desire to obtain deployable civilians. Since that time, several hundred DOD civilians have deployed, including many hired for a specific mission. The most requested skill sets are in contracting, legal, public affairs, and civil engineering.

While all of these programs have been in existence for several years (or longer), it is not clear to what extent they are being used and whether they are proving effective to meet the Department's requirements.

Implementation Action: Service secretaries audit use of existing civilian recruitment programs with an eye to determining if they are actively employed and, if they are not, to take necessary action. Within six months, provide a report on findings and actions to the USD (P&R).

Retired civilian employees are another likely source of expertise, but again the problem is how to access the skills of these retirees.

Implementation Action: Deputy Under Secretary of Defense for Civilian Personnel Policy create a database of civilian retiree skills and availability (with periodic updates) within two years.

Establish incentives for their use and propose legislation, as needed, for inclusion in the fiscal year 2012 President's Budget Request.

Find a Better Way to Utilize Contractors in Theater

Contractors provide some of the flexibility—indeed, the adaptability—that the military seeks. Contractors can be engaged at short notice, and may have already assembled the needed workforce. In essence, they act as the Department's agents, providing goods and services the military needs.

The use of contractors to produce equipment is now well-established (although in an earlier era the government did produce its own—for example, building ships in public shipyards). And the use of contractors to provide services likewise blossomed with America's decision after World War II to maintain a large standing military. Contractors have long provided training (*e.g.*, undergraduate pilot training) and maintained equipment. They were used extensively in theater during the Vietnam

conflict—for example, operating storage yards and manning forklifts at ammunition depots. The Han-Jin trucking company even ran convoys under fire in the highlands!

The use of contractors to provide services is not limited to the Department of Defense. Especially with the "reinventing government" initiative of the 1990s, the federal government sought to expand the use of contractors where it was felt they could provide a better outcome, or an equivalent outcome at lower cost.

The Department significantly expanded the use of contractors as the all-volunteer force matured, relieving military personnel of tasks (*e.g.*, kitchen patrol) that did not involve true military skills (and whose performance by military personnel made serving in the military decidedly less attractive). The result during the Balkans conflict of the 1990s was to use contractors to provide services in a deployment that in World War II or the Korean War might have been provided by military personnel.

Using contractors in this manner has proved controversial, particularly in a counter-insurgency environment without a well-defined front line, and where all personnel must be prepared to defend themselves, raising important "law of war" issues. Command and control of civilians, especially those embedded in operational units, has also raised some conflicts with the traditional government contracting structure in which a contracting officer has contractual command and control even of forces located continents away. Recent lawsuits brought by foreign nationals against contractors in United States courts for damages arising out of military operations abroad also raise questions concerning liability and immunities of contractors operating with military forces (that are themselves immune from suit). Given contractors' utility, the DSB believes their important use, especially in theater, will not diminish in the future. Therefore it is imperative that these and other issues relating to the use of civilians in deployed locations be resolved to the greatest extent possible, and that the role of contractors be clarified and strengthened.

Her Majesty's government has begun to address this challenge with the development of sponsored reserves—contractor operations where the contractor agrees that all personnel serving in a deployed theater will also hold a reserve appointment, and can be mobilized at the government's discretion, transforming a civilian staff into a military one.

Would a concept like this make sense for the United States to consider? In a modest way the Army Reserve has already taken a small step in this direction. It has begun partnering with civil employers who need trained talent that may be

difficult to recruit, and who are willing to enter a partnership in which personnel recruited and trained by the Army Reserve will be offered civil employment in that skill, with the employer understanding they will also serve in a reserve unit subject to mobilization. Programs involving truck drivers and medical personnel have been launched.

In essence, this is a public-private partnership. Exploring how such public-private partnership could give the American military the best of both worlds ought to be a priority assignment for the Assistant Secretary of Defense for Reserve Affairs. To accomplish the best use of contractors in future operations, the DSB recommends the following.

Implementation Action: Secretary of Defense:

- Task the USD (P&R), USD (AT&L), and the General Counsel to assess and clarify the use of contractors and evaluate alternatives to current use of contractors.
- Task the ASD (RA) to review the United Kingdom experience and programs like the Army Reserve initiative, both here in the United States and abroad, with an eye to producing recommendations the Secretary of Defense could consider within one year.

Access Individuals Who Can Adapt to Unforeseen Circumstances

Common sense argues that an adaptable organization is more likely to result if the individuals in it are adaptable. The military already screens entering personnel extensively and provides them with significant training to achieve its ends. Chapter 5 described activities in training by the services that relate to adaptability in degraded conditions. However, there are broader and more fundamental questions related to individual adaptability: Should such screening be more broadly extended to searching for individuals who can adapt to unforeseen circumstances? And should training include skills intended to promote adaptability of the individual and the organization? Could adjustments to career management also promote adaptability?

Military and civilian enterprises have realized real performance gains and increased productivity by using cognitive tests to select personnel and place them in appropriate jobs. By more accurately matching an individual's skills and abilities to

training and job requirements, enterprises are able to decrease costs and increase output. The U.S. military has successfully used cognitive (aptitude) tests to select and classify military members since World War II. The Joint-Service test battery, the Armed Services Vocational Aptitude Battery (ASVAB), has been used by the Services to select and classify applicants since January 1, 1976.[85] Under the auspices of the Assistant Secretary of Defense for Force Management and Personnel, the National Academy of Sciences provided technical oversight to the large-scale, multi-year effort to validate ASVAB against military job performance, known as the Job Performance Measurement Project, from July 1980 to April 1992.[86] That ASVAB predicts training and hands-on job performance is beyond question.

In addition to ASVAB, the Army developed a comprehensive set of predictor measures, including non cognitive (temperament or personality) measures, as well as a variety of performance assessments—knowledge tests, supervisory and peer ratings, and archival data, known as Project A. The result was a five-factor model of job performance with ASVAB predicting the knowledge (can do) components and temperament measures predicting the motivational (will do) aspects of performance.[87] At that time, though, the operational use of non-cognitive measures was problematic. Without right or wrong answers, individuals could succumb to responding in ways that were socially desirable, but not necessarily true; non-cognitive measures are also susceptible to faking and coaching. Considerable research efforts have been devoted to developing tools that are "fake-resistant." Efforts were redoubled as first-term attrition rates increased while recruiting became more difficult. Lowering attrition rates and expanding the recruiting market became resource issues.

While ASVAB predicts first-term attrition to some extent, it is not as good a predictor as education credential. Individuals with a traditional high school diploma are more likely to complete their service obligation than individuals with an alternative credential (GED, or General Education Development) or no credential (drop outs). This suggests a non-cognitive (motivational or temperament) component to attrition behavior. Indeed, it appears that many individuals who are separated in the early months of their enlistment failed to adapt to the military

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85. M. H. Maier, *Military aptitude testing: The past fifty years,* DMDC Technical Report 93-007, Seaside, CA, Defense Manpower Data Center, 1993.
86. Department of Defense. *Joint-Service efforts to link enlistment military standards to job performance,* Report to the House Committee on Appropriations, Washington, DC, Office of the Assistant Secretary of Defense (Force Management and Personnel), 1992.
87. J. P. Campbell, J. J. McHenry, and L. L. Wise, "Modeling job performance in a population of jobs," *Personnel Psychology*, 43(2), 313-333, 1990.

environment—even with above average ASVAB scores. Starting in 2000, the Army was able to use a temperament measure evolved from Project A, the Assessment of Individual Motivation (AIM), to screen high attrition risk, non-high school diploma graduate applicants. AIM is a self-report instrument that measures dependability, adjustment, leadership, agreeableness, achievement, and physical conditioning. The Army continues to use AIM in an operational test and evaluation (OT&E) mode, as it continues to refine the screening process for non-high school diploma graduates.

In addition to AIM, the Army has recently developed a computer-administered assessment, Tailored Adaptive Personality Assessment System (TAPAS), based on state-of-the-art testing technology. It is expected that TAPAS will be more accurate, less vulnerable to coaching and social desirability issues, and more flexible in terms of the temperament factors and facets that may be assessed. As currently configured, TAPAS measures 13 facets of the big five personality dimensions: openness, extraversion, agreeableness, conscientious-ness, neuroticism/emotional stability. The Army is preparing to begin OT&E data collections with applicants; other Services have shown interest and will also collect data on their applicants.

The U.S. Army Research Institute conducts an ongoing research program to improve the selection, development, and retention of soldiers in the Special Operations Forces (SOF).[88] After identifying the attributes required for successful performance in SOF, this information was used to develop a state-of-the-art selection tool, Test of Adaptable Personality (TAP), which is demonstrably related to SOF field performance. The TAP can be used to improve selection decisions or to guide self-development by providing valuable insight about critical strengths and weaknesses.

In one study, the TAP significantly predicted SOF enlisted soldier field performance as measured by ratings obtained from the soldiers' immediate superiors. In another study, the TAP predicted the field performance of officers leading their SOF teams through a highly realistic, two-week exercise simulating Special Forces field missions. In both studies the TAP results compared favorably to those obtained from physical and mental tests, as well as other psychological tests. In a third study, the TAP scales predicted completion of special mission unit selection and training. Research in non-SOF settings reveals that selected TAP scales predict the advancement of lieutenant colonels at the Army War College to the rank

88. R. Kilcullen, *The Test of Adaptable Personality (TAP),* Information Paper, Arlington, VA, U.S. Army Research Institute for the Behavioral and Social Sciences, 2006.

of general officer, as well as the job performance of Department of the Army civilian supervisors, managers, and senior executive service leaders.

The TAP is a 121-item multiple-choice test that takes about 30 minutes to complete. It measures job-relevant temperament attributes and also includes a "response distortion" scale that detects and adjusts for deliberate faking on the part of the respondent. Some of the temperaments measured by the TAP include:

1. **Achievement orientation**. Working hard towards task accomplishment and giving one's best effort.
2. **Cognitive flexibility**. Willingness to try innovative approaches for getting work done, and tolerating uncertainty and ambiguity.
3. **Peer leadership**. Willingness to assume positions of authority and responsibility.
4. **Fitness motivation.** Willingness to maintain a demanding exercise regimen.
5. **Interpersonal skills, team player**. Willingness to work cooperatively and get along well with others.
6. **Interpersonal skills, diplomat**. Being extroverted and outgoing; able to make friends easily and establish rapport with strangers.
7. **Self efficacy**. Maintaining one's confidence and composure under stress.
8. **Personal discipline**. Willingness to respect legitimate authority figures and to follow rules/regulations.

The Navy has also developed a non-cognitive instrument to assess attrition risk of their Special Forces, SEALS. The Navy Computer Adaptive Personality Scales (NCAPS) measures achievement, adaptability and flexibility, attention to detail, dependability, dutifulness and integrity, self-reliance, social orientation, stress tolerance, vigilance, and willingness to learn. Nine additional traits are being tested for officers: leadership orientation, perceptiveness and depth of thought, innovation, initiative, tolerance for ambiguity, empathy, self-control, commitment, and positive self-concept. The Navy non-cognitive measures are able to predict performance (those who would request to be dropped from training) of basic underwater demolition/seal trainees. NCAPS is also being used as part of a computer-based training effectiveness study to examine the interaction between training delivery and personality.

The military has just scratched the surface of the potential for non-cognitive measures. Important first steps have been taken to demonstrate that personality traits predict useful aspects of performance. It remains an open question whether existing non-cognitive measures can be helpful in predicting which individuals will perform better in an uncertain environment at the tactical and operational levels, and none of the work done to date provides any guidance regarding methods to predict the adaptability of organizations. The DSB believes that the Defense Department should expand its ongoing research into the relationship between non-cognitive measures and performance in real world circumstances such as in the field in Iraq and Afghanistan.

With the above goal in mind, the starting point must be a definition of adaptability. The dictionary defines adaptability as "able to adjust readily to different conditions." Mueller-Hanson, White, Dorsey, and Pulakos define it as, "an effective change in response to an altered situation;"[89] while this summer study is using, "the ability to bring about timely and effective adjustment or change in response to the surrounding environment," as its initial working definition. The Army has also used the term "mental agility" as a desirable personnel trait, referring to it as "flexibility of mind, a tendency (or capacity) to anticipate or adapt to uncertain or changing situations.[90] However, as the authors note, this definition contains overlapping terms related to mental agility (*e.g.,* adaptation, creativity), but limited empirical research has been done to examine their relationship to mental agility.

Individual Adaptability

However defined, adaptability in individuals is likely to be influenced by genetics, experience, and context; research might be able to identify the relationships and interactions among these variables and performance. Rumsey noted that successful adaptive performance is likely to result from a combination of cognitive, temperament, and motivational factors.[91] Pulakos *et al.* has identified just such

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89. R. A. Mueller-Hanson, S. S. White, D. W. Dorsey, and E. D. Plakos. *Training Adaptable Leaders: Lessons from Research and Practice,* ARI Research Report 1844, Arlington, VA, U.S. Army Research Institute for the Behavioral and Social Sciences, 2005. R. Kilcullen. *The Test of Adaptable Personality (TAP),* Information Paper, Arlington, Va., U.S. Army Research Institute for the Behavioral and Social Sciences, 2006.
90. G. A. Goodwin, J. S. Tucker, J. L. Dyer, and J. Randolph. *Science of human measures workshop: Summary and conclusions,* ARI Research Report 1913, Arlington, Va., U.S. Army Research Institute for the Behavioral and Social Sciences, 2009.
91. M. G. Rumsey. "The best they can be: Tomorrow's soldiers," *Future soldiers and the quality imperative: The Army 2010 conference,* R. L. Phillips and M. R. Thurman (Eds.), Fort Knox, Ky., The United States Army Recruiting Command, pp. 123-158, 1995.

relationships between predicted ratings of adaptive performance and cognitive ability, emotional stability, and achievement motivation in a variety of occupations.[92] Similarly, Kilcullen *et a*l. found that peer ratings of officer performance was predicted by leadership self-efficacy, achievement orientation, intellectual openness, and tolerance of ambiguity in an exercise where participants were required to react to changed circumstances—to adapt.[93]

Additional cognitive attributes may be identified. Rumsey[94] cited work by Mathew and Stemler[95] on pattern recognition and mental flexibility, cognitive complexity[96] and intuition, and critical and creative thinking[97] that may be promising.

With respect to experience, Rumsey[98] noted that "Pulakos et al. found a strong link between experience and adaptive performance … learning work tasks, technologies, and procedures … correlated with adaptive performance."[99] Hence, one would expect the training environment to play an important role in the development of adaptive behavior and skills that might generalize to other (job) contexts. Contextual variables, such as the amount of control an individual has in a situation, work level (rank), requirements of the job, etc. may inhibit or enhance adaptable performance.[100]

As one example of an adaptable work taxonomy, Pulakos et al. empirically identified eight dimensions of adaptable behavior: handling emergencies; handling work stress; solving problems creatively; dealing with uncertain and unpredictable work situations; learning work tasks, technologies, and procedures; demonstrating interpersonal adaptability; demonstrating cultural adaptability; and demonstrating

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92. E. D. Pulakos, N. Schmitt, D. W. Dorsey, S. Arad, J. W. Hedge, and W. C. Borman, "Predicting adaptive performance: Further tests of a model of adaptability," *Human Performance*, 15, 299–323, 2002.
93. R. Kilcullen, J. Goodwin, G. Chen, M. Wisecarver, and M. Sanders, "Identifying agile and versatile officers to serve in the Objective Force," Presented at the Army Science Conference, 2002.
94. M. G. Rumsey. "Selecting Adaptable Military Personnel: A Research Agenda," Personal communication, 2010.
95. C. T. Matthew and S. Stemler, *Exploring pattern recognition as a predictor of mental flexibility,* 2008 (draft).
96. N. G. Peterson, D. Smith, R. G. Hoffman, E. D. Pulakos, D. Reynolds, B. C. Potts, S. H. Oppler, and D. L. Whetzel, Personal communication, 1993.
97. W. R. Burns and W. D. Freeman, *Developing an adaptability training strategy and policy for the DoD: Interim report,* IDA Paper P-4358, Institute for Defense Analyses, 2008.
98. M. G. Rumsey, "Selecting Adaptable Military Personnel: A Research Agenda," Personal communication, 2010.
99. E. D. Pulakos, N. Schmitt, D. W. Dorsey, S. Arad, J. W. Hedge, and W. C. Borman, "Predicting adaptive performance: Further tests of a model of adaptability," *Human Performance*, 15, 299–323, 2002.
100. M. G. Rumsey, "Selecting Adaptable Military Personnel: A Research Agenda," Personal communication, 2010.

physically oriented adaptability.[101] As Rumsey notes, "In order to have meaningful measures of adaptability, it is desirable that those evaluated are actually placed in situations where adaptable performance is elicited."[102] Such situations may be constructed—as in training exercises—or natural, as in actual work (combat) situations. Once a model of adaptable behavior is developed, performance rating scales may be devised.

The ongoing operations in Iraq and Afghanistan provide real world opportunities to test hypotheses about the relationship between various measures and real world performance. Therefore, the DSB recommends that the Services conduct appropriate large-scale experiments to determine if the existing tests are in fact useful for predicting performance in the field.

Implementation Action: The USD (P&R), in coordination with the Service secretaries:

- Pick a definition for individual adaptability and the traits associated with it.
- Select one or more tests believed to predict individual adaptability.
- Begin administering those tests as a basis for analyzing the relation between adaptability traits and performance.
- As a separate initiative, test deploying forces for adaptability at the start of spin-up training, at time of deployment, and upon return from deployment.
- Use these accumulated data to determine correlation of screening scores to performance, including performance on deployment and the separate effects of training and the deployment experience itself.

In parallel with this work, the USD (P&R) commission a competitive research process to identify the "best" temperament screen.

Rumsey has provided the summer study with a concise paper describing a potential program of research to determine components of adaptability (Appendix E).[103] While the DSB cannot endorse this specific proposal as the best way forward, it is illustrative of a thoughtful set of research steps: construct a developmental model of

101. E. D. Pulakos, N. Schmitt, D. W. Dorsey, S. Arad, J. W. Hedge, and W. C. Borman, "Predicting adaptive performance: Further tests of a model of adaptability," *Human Performance*, 15, 299–323, 2002.
102. M. G. Rumsey, "Selecting Adaptable Military Personnel: A Research Agenda," Personal communication, 2010.
103. M. G. Rumsey. "Selecting Adaptable Military Personnel: A Research Agenda," Personal communication, 2010.

adaptability, develop individual difference measures to predict adaptable performance, develop measures of adaptable performance, validate predictor measures against performance measures, refine measures/strategies as needed based on findings, and make recommendations to DOD based on findings.

Train Individuals to Adapt to Unforeseen Circumstances

All of the military services have established programs to train deploying forces in realistic scenarios as part of their respective force generation efforts for Iraq and Afghanistan. These efforts include pre-deployment training focused on urban warfare skills, and often include scenarios in which troops interact with Iraqi and Afghan role players in highly realistic settings. The purposes of this type of training are many. First, and perhaps foremost, is to reduce the scope of the unexpected and to learn, by doing, how to respond appropriately to events that may occur in theater. The Army has also made a sustained effort to expose deploying forces to the latest intelligence and TTPs that are available from the specific areas to which a force will be deploying. These efforts include linking deploying units over the Internet to the force that will be replaced for several months prior to deployment. The civilian sector has also recently begun similar training at facilities manned by the Indiana National Guard and contractor forces.[104]

Realistic pre-deployment training is clearly an important part of reducing the scope of uncertainty that deployed forces will face. However, a question remains whether realistic pre-deployment training can also enhance individuals' adaptable behavior in the sense that the training also leads to better outcomes in battlefield scenarios for which there was no training.

To answer this broader question, the Institute for Defense Analyses (IDA) is developing an adaptability training strategy and assisting in the development and execution of a related proof-of-concept experiment.[105] From its summary, the efforts thus far yield several major findings:

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104. Kristin Henderson. "This is war. As a civilian USAID worker in Afghanistan, you can expect tough negotiations with tribal leaders, anger from villagers and constant enemy fire. And that's before you actually get there." *Washington Post Magazine,* July 4, 2010, W22.
105. W. R. Burns and W. D. Freeman. *Developing an adaptability training strategy and policy for the DoD: Interim report,* IDA Paper P-4358, Alexandria, Va., Institute for Defense Analyses, 2008.

- Validation of the IDA model of adaptability, which integrates both cognitive and relational aspects of performance and has practical meaning for implementation of learning initiatives.
- Confirmation that adaptability learning is a function of education, experience, and training, with the greatest adaptability learning taking place in situations where learning in one sphere (*e.g*., education) is reinforced by similar learning in both of the other spheres(*e.g*., experience and training).
- Indications that the key to developing adaptable leaders, leader teams, and units at every level is repeated exposure to "crucible experiences" commensurate with the operational environment and level of responsibility of each.
- Acknowledgment of the need to enhance the adaptability of individuals, units, and commander/leader teams, although Burns and Freeman found only two examples of purpose-designed adaptability training and no examples with metrics to measure the effectiveness of the training.

Burns and Freeman report that:

> …there is also some evidence that a mastery orientation toward adaptability training might improve adaptive performance. When people hold mastery or learning goals for a task (such as a training course), their main objective is to master the knowledge and processes that underlie performance. These types of goals are in contrast to performance goals, where the main object is to achieve a particular level of performance during training. When people hold mastery goals, they are more likely to look upon difficult training situations as learning experiences, rather than as situations to be avoided because they may interfere with performance. Furthermore, because a mastery orientation involves treating mistakes as opportunities to learn, people with mastery goals tend to get less frustrated in the face of failure than do those with performance goals. This may make them more resilient in maintaining performance out of the training context and under demanding conditions than people learning under a performance orientation. A mastery orientation can be encouraged in training by deemphasizing grades and quantitative performance ratings and focusing instead on providing feedback on how students can leverage their strengths for continuous improvement.[106]

In any personnel system there is typically a trade-off between selection/ classification and training. To what extent do you select individuals from a population

106. W. R. Burns and W. D. Freeman. 2008.

with particular skills and abilities for a job, rather than provide the necessary skill training? The answer lies in the availability of the particular skill in the population and the trainability of the skill or ability itself. This is rarely an either/or decision and the solution will need to take into account the cost of training. If a particular ability is widely available and difficult to train, then selection would be key to acquiring individuals with that skill. On the other hand, if the skill is sparsely distributed in the population, but easy to train (low training cost), then an emphasis on training solutions would be preferred. The trade-off for less extreme cases poses the challenge, and the location of "adaptability" (common or rare) in the problem space is not yet established. Better integration of selection/classification and training research programs would help to address this issue.

It is realistic to expect that DOD can do a better job of identifying and training individuals to be adaptive performers. A thoughtful plan that includes attention to both selection and training disciplines is probably required. However, a comprehensive research framework and empirical data are necessary to devise such a plan. DOD has some established cognitive and non-cognitive tests that could be administered to all applicants for enlistment. While this may not represent a complete set of measures (we know, for example, that the cognitive test battery, ASVAB, does not include a measure of perceptual speed), it would be a good start for establishing a baseline for such research. Performance measures from training (where adaptable behavior is elicited from trainees by altering conditions under which behavior was initially trained—*e.g.*, degraded conditions), supervisor ratings, and archival sources (promotion rates, retention rates, awards, etc.) would then need to be developed and/or collected. The current environment may also present an opportunity to accumulate unprecedented information from actual mission events while fresh in military members' experiences. Exemplars of good and poor adaptive behaviors can be used to develop behaviorally anchored rating scales for performance measures. Such information may help advance military selection, classification, and training tools.

One recommendation to move this endeavor forward would be to establish an OSD-level research program (in the Office of the USD (P&R), co-sponsored by Readiness (for training) and Military Personnel Policy (for selection)) with joint Service participation by the relevant research and development laboratories. Training Transformation Funds could be used to enhance the Services' research related to adaptability and assure a coordinated research program. This concept would be similar to the OSD Job Performance Measurement Program that established the relationship between cognitive skill (measured by ASVAB) and

military readiness (measured by hands-on job performance). Key to this effort would be cooperative efforts among the personnel and training communities, OSD, and Services. This program, itself, would serve as an example of organizational adaptability, as funds would be employed across research areas and used to foster integration of research results.

Career Management: Promotion, Separation, Retirement, Recall

Careers of the Department's military personnel, active and reserve, are currently managed within a restrictive set of laws, regulations, and policies, all reinforced by culture and tradition. Many of these laws and regulations have been in force fifty years or more. They all may not have been sensible fifty years ago, but the DSB believes they certainly have the effect today of inhibiting the Department's flexibility and adaptability, lessening its ability to use and deploy people efficiently, and ultimately wasting human capital. Prominent examples include a compensation system that encourages personnel to retire at 20 years of service when, especially for the technically trained, they are at the peak of their productivity; mandatory retirement for almost all at 30 years though some still have many potential years of useful service remaining; and rigid career paths that do not allow easily for the development of and rewards for key technical skills (*e.g.*, information technology) or important management experience (*e.g.*, acquisition program management). Recommendations for thorough reform of this system are beyond the scope of this study, but the DSB believes some important steps can be taken now.

Implementation Action: Secretary of Defense

- Task USD (P&R), together with the military departments, to review within six months the extent to which existing exception authorities (*e.g.*, "retire and retain" authority) are being used and recommend actions to increase and enhance their use and effectiveness.
- Task USD (P&R), together with the military departments, to assess the extent to which current policy and law facilitates the selection (for promotion, assignment, recall, etc.) and reward of personnel who have demonstrated adaptability and recommend action and legislation to improve the Department's ability to select and reward for that trait.

Organization Adaptability and Personnel Attributes

The interest of this study is in effective outcomes and, therefore, in organizational adaptability. Intuition suggests that an adaptable organization requires adaptable individuals. But how many are needed? In which positions? In what mix? And could the effective choice of incentives reinforce adaptability, or perhaps even substitute for some of the individual traits the Department might otherwise seek?

It is widely believed that adaptable leaders are necessary for adaptable organizations, as leadership can be critical to changing an organization's direction. DOD's recent experience in acquiring foreign language skills is one example of the importance of effective leaders. In the past, foreign language skills were generally viewed as province of the intelligence community. But the Department's recent experiences in counter-insurgency operations have changed that perspective. Today, foreign language skills are needed by a broad cross-section of the force—seen as war fighting skills by uniformed leaders. In fact, some military leaders are beginning to advocate foreign language proficiency as an expectation for future officers. These changes, which have occurred over the past decade, are due in large measure to energetic leadership—including providing the resources necessary to underwrite the change. (See Appendix B for further details on DOD's language transformation.)

Adaptability literature also argues that a leader's approach to his or her responsibilities promotes organizational adaptability. Leaders who demonstrate openness to suggestions, for example, secure organizational adaptability. Mueller-Hanson further argues that leaders "must … develop adaptability in their teams by encouraging and rewarding adaptive behavior in the team".[107]

It is likely that the nature of adaptability varies with the level of the organization, as well as the nature of the organization and its mission. Military adaptability at the tactical level may call on a different set of traits, knowledge, and preparation than at the operational or strategic level. Having knowledge of military history for those in senior military leadership positions is a case in point (*e.g.*, Murray).

Preparation is likewise believed to promote organizational adaptability. This is the thesis behind much of military unit training, and especially the mission rehearsal exercises that now precede most major deployments. These exercises may involve allied and indigenous leaders and those familiar with local culture, who bring to the

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107. R. A. Mueller-Hanson, S. S. White, D. W. Dorsey, and E. D. Plakos. *Training Adaptable Leaders: Lessons from Research and Practice,* ARI Research Report 1844, Arlington, VA, U.S. Army Research Institute for the Behavioral and Social Sciences, 2005.

exercise situations similar to those in which the unit may encounter at both the tactical and operational level, and against which the unit can test both its prior training and its procedures. Familiarity with situations makes it easier to adjust once actually deployed, allowing service members to practice how they might adapt when confronted with similar circumstances in theater. This same thesis motivates the case for training under degraded conditions, discussed in the earlier chapter on this subject.

It might also be argued that the procedures within which individuals and organizations work, and the equipment they use, can also promote organizational adaptability. This proposition motivated the Navy and the Air Force to begin demonstrations in the 1980s of interactive electronic technical manuals, replacing the paper media historically employed. DOD-wide specifications were initially published in 1992. The effort included integrating the interactive manuals with such maintenance-support functions as diagnostics, on-line fault reporting, and debriefing.[108]

While job performance aids have been subjected to explicit tests that would earn scientific respect, much of the rest of the literature on organizational adaptability rests on just a few case studies. The significant set of deployments to Iraq and Afghanistan provide an opportunity to better test these propositions, both *ex post* using the "natural experiments" these deployments have created, and *ex ante* with the several years of deployments likely to occur. One simple analysis might involve interviewing senior commanders, inviting them to assess the adaptability of units under their command, and then testing for associations between those assessments and the characteristics of those units and their personnel. We recommend that such a program of research begin, perhaps carried out by the war colleges.

At the same time, adaptability at the enterprise level would be enhanced by establishing a more immediate connection between issues arising from current operations and the secretaries of the military departments. Whatever its other virtues, one of the unintended consequences of the Goldwater-Nichols Act is to divorce the Service secretaries from current operations, except as they respond through the lengthy budget development process. Yet the Service secretaries exercise enormous authority that could be used to reallocate personnel, resources, and effort within the budget cycle to meet operational needs. Hence the recommendation for a "Secretary's Council" advanced in the following chapter of this report.

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108. Eric L. Jorgensen and Joseph J. Fuller. *New Approaches for Navy Technical Training and Job Performance Aiding Using Expanded IETM Technology*, Carderock Division, Naval Surface Warfare Center, October 1996.

Summary of Recommendations

The Under Secretary of Defense for Personnel and Readiness (USD (P&R)) develop within six months an initial personnel strategy (in coordination with each military department). This strategy should determine the types of skills that have been and will be required for ongoing and future operations, and the methods to be used to acquire those skills:

To assess and acquire needed skills:

- Each Service assistant secretary for manpower provide a plan for creating a similar skills inventory with the goal of reporting to the USD (P&R) within six months and that the USD (P&R) then work with the Services to propagate those systems that seem most promising.
- Assistant Secretary of Defense for Reserve Affairs (ASD (RA)) create within the next two years an all-service National Guard and reserve database to capture civilian skills and experience.
- ASD (RA) undertake an effort to tabulate key skill shortfalls identified by combatant commanders over the last three years and work with other principal staff assistants to establish requirements for future needs. Establish goals for recruitment.
- The ASD (RA) create, within one year, a database of retirees and their military and civilian skills within one year, for potential future call-up use, and to maintain that database with periodic updates.
- Service secretaries audit use of existing civilian recruitment programs with an eye to determining if they are actively employed and, if they are not, to take necessary action. Within six months, provide a report on findings and actions to the USD (P&R).
- Deputy Under Secretary of Defense for Civilian Personnel Policy create a database of civilian retiree skills and availability (with periodic updates) within two years.

To further use of contractors, Secretary of Defense:

- Task the USD (P&R), USD (AT&L), and the General Counsel to assess and clarify the use of contractors and evaluate alternatives to current use of contractors.
- Task the ASD (RA) to review the United Kingdom experience and programs like the Army Reserve initiative, both here in the United States and abroad,

with an eye to producing recommendations the Secretary of Defense could consider within one year.

To assess adaptability in individuals:

- The USD (P&R), in coordination with the Service secretaries:
  - Pick a definition for individual adaptability and the traits associated with it.
  - Select one or more tests believed to predict individual adaptability.
  - Begin administering those tests as a basis for analyzing the relation between adaptability traits and performance.
  - As a separate initiative, test deploying forces for adaptability at the start of spin-up training, at time of deployment, and upon return from deployment.
  - Use these accumulated data to determine correlation of screening scores to performance, including performance on deployment and the separate effects of training and the deployment experience itself.
- In parallel with this work, the USD (P&R) commission a competitive research process to identify the "best" temperament screen.

To incorporate adaptability into career management:

- Secretary of Defense
  - Task USD (P&R), together with the military departments, to review within six months the extent to which existing exception authorities (*e.g.*, "retire and retain" authority) are being used and recommend actions to increase and enhance their use and effectiveness.
  - Task USD (P&R), together with the military departments, to assess the extent to which current policy and law facilitates the selection (for promotion, assignment, recall, etc.) and reward of personnel who have demonstrated adaptability and recommend action and legislation to improve the Department's ability to select and reward for that trait.

Chapter 7. Change the Culture

The goal of adaptability is to prepare the enterprise to be effective in an uncertain environment. Achieving the level of adaptability demanded by today's challenges will require a major transformation that spans many aspects of the Department's operations. Transformation succeeds when culture, strategy, vision, processes, incentives, and accountability are aligned and reinforce one another. Culture focuses on the human element of adaptability. Moving away from core rigidities that prevent the enterprise from being as effective as possible can only be achieved by changing the way individuals think about their roles and how they help achieve the overarching goal of the organization.

In his book *Leading Change*,[109] Harvard professor John P. Kotter, an authority on leadership and change, proposes an eight-step process for initiating a transformation:

1. Establish a sense of urgency.
2. Create a guiding coalition.
3. Develop a vision and strategy.
4. Communicate the change vision.
5. Empower broad-based action.
6. Generate short-term wins.
7. Consolidate gains and produce more change.
8. Anchor new approaches in the culture.

Kotter's *Harvard Business Review* article "Leading Change: Why Transformation Efforts Fail" lists the mistakes companies make when attempting to reengineer themselves. One of the most common errors is not anchoring changes in the organization's culture:

> Change sticks when it becomes "the way we do things around here," when it seeps into the bloodstream of the corporate body. Until new behaviors are rooted in social norms and shared values, they are subject to degradation as soon as the pressure for change is removed. [110]

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109. John P. Kotter. *Leading Change*, Harvard Business School Press, 1996.
110. John P. Kotter. "Leading Change: Why Transformation Efforts Fail," *Harvard Business Review on Change*, Harvard Business School Press, 1998.

Senior leaders see change as opportunity, whereas those further down in the organization see change as a threat. Attempts at broad change inevitably give rise to skepticism, particularly when previous efforts were viewed as failures. Changing the rules of the game makes people uncomfortable and can provoke obstructionist behavior. Organizational barriers are created when people use processes and regulations to protect their turf. Acknowledging and addressing cultural issues is critical when introducing changes that require new ways of thinking and behaving. The degree of leaders' appreciation for the role of organizational culture can determine the success or failure of a transformation effort.

Cultures can change when leaders make a compelling case for change, there is a clear roadmap of explicit steps, the roadmap is consistently communicated to all stakeholders, and expectations and accountability are unambiguous.

Case studies from the DOD and industry. This study has shown many parallels between the challenges that the DOD faces and those faced by industry. The case studies in Appendix A give examples of adaptation, both successful and unsuccessful, in both commercial and defense organizations. Those that adapted successfully acknowledged the role of culture change and realized that true transformation is about much more than process reengineering:

- **Cisco** became one of the most valuable companies in the world by staffing projects with people who are capable of learning and adapting.
- **Cemex** grew from a small, local building materials supplier to one of the top global companies in the industry by empowering teams and giving them the authority to make important business decisions.
- **Ericcson** rebounded from heavy losses after the telecommunications crash by consolidating functions and challenging the traditional culture and approach to research and development.
- **Ford** went from the verge of bankruptcy to posting a $2.7 billion profit by making culture changes that improved the alignment of all functional elements.
- **IBM** returned to profitability by changing the culture from that of "box maker" to service provider.
- **Intel** became one of the most powerful brands in the technology industry by encouraging innovative thought and challenging assumptions at all levels of the corporation.

There is plenty of evidence that cultural change is difficult. Likewise, a review of the key attributes of adaptable organizations shows that an aligned culture is a key component of organizational effectiveness. The actions called for in this report are fundamentally culture-changing.

Achieving Adaptability by Driving Cultural Change

The DSB believes that the recommendations in this report will bring about a culture change that will enable the DOD to reach new levels of responsiveness and adaptability. Carrying them out successfully will require recognition of both the process changes required and the cultural affects of those changes.

Aligning enterprise functions to support mission objectives involves getting the whole community focused on shared mission outcomes—a major cultural change. Today the various elements of the enterprise are focused on their own organization-centric goals. For example, the test regimen for the Ground Combat Vehicle was estimated by the Army acquisition executive to consume three calendar years, delaying the delivering of much needed capability. Creating a sense of urgency will be just as important as installing processes that enable faster response.

Reducing uncertainty through the use of **hedging and shaping strategies** represents a culture change because those strategies move the department toward *risk management* and away from *risk avoidance*. Hedging encourages placing small bets as opposed to making a single major investment. Shaping puts the focus on the longer term, imparts a need for greater global awareness, and enables stakeholders to define the future environment rather than operating exclusively in reactive mode.

Preparing for degraded operations requires a culture that can react quickly to surprise circumstances. That culture must exist not only on the battlefield but also throughout the enterprise. Understanding the critical operational dependencies on communications, cyber, and space systems provides the opportunity to prepare backup plans and mitigation approaches for current and future threats. Adaptability can be further enhanced with more realistic training environments and tools to enable operating in degraded mode.

Enhancing the adaptability of the workforce requires culture-changing personnel practices that focus on information and knowledge workers rather than an industrial base workforce. These recommendations are intended to create access to a much larger pool of resources and create capability reserves at the ready. The

intent is to shift the focus from simply filling billets to getting the right skills in the right place at the right time.

Steps to Accelerate Culture Change

The recommendations of this study are aimed at ensuring that the DOD can be effective in an uncertain environment. But achieving the desired outcomes will also require a fundamental culture change throughout the DOD enterprise. The following recommendations complement those made in previous chapters and create a "tone at the top" necessary for enduring change.

RECOMMENDATION: CHANGE CULTURE

Take explicit steps to instill adaptability as a core value and shift DOD's culture from one of risk aversion to one that emphasizes outcomes, risk management, and efficiencies in how the Department operates.

Secretary's Council

In an organization as large as DOD there are bound to be complex and intractable problems. For example, suboptimal organizational structures form over time and create stove pipes and artificial boundaries with respect to resource allocation. These organizations may also project vastly different incentive structures that can operate at cross-purposes.

Real world experience further illustrates how these issues impact critical operations. The Department of the Army found itself short of medevac (medical evacuation) capacity for Afghanistan. However, DOD had sufficient medevac capacity residing mainly with Department of Navy assets. The seemingly straight forward transfer of Department of Navy assets to the Army was far less timely than desired and required executive level intervention. This situation is not uncommon and reveals that few mechanisms are available to reconcile mission needs with enterprise-wide resources. The Department suffers continuing challenges in managing high-demand, low-density capabilities—that is, capabilities that are in high demand in current operations, but are in limited supply in the force. These capabilities cover the spectrum of force structure from ISR platforms to civil affairs units. Further, the utility of the high-demand, low-density asset may be viewed differently by different enterprise entities, causing resource contention without expeditious means of reconciliation from an enterprise perspective.

Implementation Action: Secretary of Defense establish a **Secretary's Council**, comprised of the Service secretaries, to ensure that the vast array of enterprise resources that they command are responsive to the needs of the theater on a joint basis. During times of conflict, the council ensures that requests for supplemental funding and reprogramming of existing funds address the most significant shortfalls identified by the combatant commanders. The Secretary's Council recognizes that increased agility is required during times of "hot" war and models the value of leveraging all resources to achieve a shared mission outcome.

From the Cold War to "hot" wars. The Department of Defense successfully honed its resource and acquisition processes to win the Cold War. But the Secretary of Defense's interventions to speed the procurement and deployment of Mine Resistant Ambush Protected Vehicles for Iraq, and to expand intelligence, surveillance, and reconnaissance capacity for Iraq and Afghanistan (the "Liberty" program), argue that some important adjustment is needed for prolonged "hot" wars of the kind in which the United States is engaged.

In the Cold War, the needs of combatant commanders and the responses of the military departments were brought together through the promulgation of scenarios to which the program objective memoranda responded—responses that were reviewed, analyzed, debated, and shaped into the President's budget request and the five-year defense program. The long-term, strategic nature of the conflict provided the time and bureaucratic space for such careful deliberation, in which initial decisions were often made two years before their intended implementation.

A more agile mechanism for today's war. The "hot" conflict for which the process prepared the United States was presumed to last just a short time, perhaps only a few weeks or months, creating little need for a wartime mechanism with which to adjust military programs. In contrast, in a long conflict against enemies who are constantly changing their tactics in response to U.S. actions, a more agile coordinating mechanism may be needed. The military departments should play a timelier role, in that the training and equipping of the force must be updated constantly with the operational environment, and on a joint basis. In short, the resource allocation and acquisition processes need to adapt to deal better with these changed circumstances.

A model for immediate response. Interestingly, in their proposals for a National Security Organization in 1947, the War and Navy Departments recommended that a

War Council be created, chaired by the Secretary, and composed of the military department secretaries and Service chiefs. The National Security Act of 1947 accepted that advice and charged the council with advising the Secretary of Defense on "matters of broad policy relating to the armed forces." At several points in the 1950s, it appears the council did indeed play an important role in deciding immediate departmental responses to real-world events.

But the council did not play that role during the early stages of the Vietnam War, nor the later part of the Cold War. It was not used for the (first) Persian Gulf War and had been completely abandoned by the time of the Balkans conflicts. While the Department has adjusted in many ways since the 1990s, the broad outlines of the resource and acquisition processes continue to conform to the model used to prosecute the Cold War successfully to its conclusion. That model may continue to be relevant for making the Department's long-run investment decisions, but not for responding to the changes needed in the short run to prosecute current conflicts, especially to deal with surprises, and with changes that must involve the most senior leaders of the Department.

A small team for prompt problem resolution. How might a Secretary's Council work in the hot wars of today? First, to be effective, it ought to be as small as possible: the Secretary of Defense (or his Deputy); the Chairman of the Joint Chiefs of Staff; the military department secretaries; the under secretaries for acquisition, personnel, and comptroller; and perhaps the Director, Cost Assessment and Program Evaluation. Second, its charge should be to resolve *problems* in meeting the needs of the combatant commanders *promptly.* This implies using existing resources in new and different ways wherever possible, and if new materiel must be acquired, capitalizing on emergency authorities (creating or seeking new such authorities where necessary).

The council would not replace current wartime processes—for example, the often-weekly meetings of the Secretary and the Chairman (and selected OSD staff) to decide which forces should be deployed (including which reserve component units should be mobilized). Rather, it is those needs that the extant processes do not meet well that should be the focus of the council (*e.g.*, Requests for Force that are closed without being met, or that are met only by taking steps that violate standards the Secretary has set).

The rhythm of the council might well be synchronized with the rotational pattern that governs current force deployment of all the Services. Ensuring that the equipping and training received by the units, for example, is adjusted to the needs of the theater on a joint basis could well be an important responsibility. And ensuring that requests

for supplemental funding and reprogramming of existing funds meet the most significant shortfalls identified by the combatant commanders could also be one of the council's tasks.

Eliminating seldom-employed processes. Are there existing bodies or processes that could be eliminated to provide the latitude for creation of a Secretary's Council? The first direction in which to look would be those that are seldom employed by the current Secretary of Defense (*e.g.*, the Senior Leader Review Group, the Defense Senior Leadership Conference, and the Reserve Forces Policy Board), or that add little value.

Could an existing body or process be employed? Conceivably. Indeed, the antecedent to the Senior Level Review Group, Defense Senior Leadership Conference, and Deputy's Advisory Working Group, the Defense Planning and Resources Board (earlier the Defense Resources Board), had some of the desired characteristics. But like the present-day entities, its responsibilities were focused on the strategic resource decisions of the Department. One has to reach back to the lessons learned in the Second World War to find the precedent for what we might once again consider to create the adaptability the Department requires.

The Secretary's Council agenda illuminates process deficiencies and creates an opportunity for enduring improvements. Experience suggests that streamlining processes of complex organizations is extremely difficult without consistent, focused attention of top management. Numerous examples exist of organizations that challenge their teams to "reengineer" or "eliminate," only to discover that, after extensive work, teams concluded that every activity had an important reason for existing and could not be eliminated. To succeed, process improvement initiatives must have explicit direction and protection from top management and the Secretary's Council provides a mechanism to make visible areas in need of change and a driving force for immediate action.

Appointing a leader for process change. A primary focus of the council is the transformation of all DOD organizations to match the pace and adaptability of war fighters. Because the experience to carry out this change is not readily available in the department, the DSB recommends that the Secretary appoint an experienced special assistant or chief of staff for process improvement, with a proven track record of reengineering a complex commercial organization, to spearhead a formal reexamination of defense processes. This person should sit in the Secretary's office, establish the Secretary's Council agenda, and have full and visible support of the Department's leadership.

Waivers: Move from a Risk-Averse to Risk-Managed Approach

One of the key attributes of successful commercial organizations is the willingness to examine how the firm does its work and to abandon processes that consume resources but don't create value for the mission. The DOD, conversely, has a long history of repeatedly layering new initiatives on existing processes with a goal of minimizing risk. As a result, doing most things in the Department is more difficult, takes longer, and requires too many reviews and approvals. To compound this process-heavy environment, the culture of risk aversion means that "no" is much more likely to be encountered than "yes."

Congress has granted the Department significant waiver authority in many areas, but the Department has been historically reluctant to use it. Use of waivers is an area in which culture change is needed. In the current environment, program managers perceive a stigma associated with the use of waivers and tend to avoid them. The fact is that waivers can be beneficial when the circumstances warrant. In addition to overcoming obstacles, proper analysis and evaluation of waiver usage identifies those policies, rules, and regulations that need to be changed to allow the Department to function more effectively in today's operational environment.

Making use of waivers easier. Useful information may be gained from the experience of pilot programs, as well as from waivers granted more broadly across the Department. All the under secretaries of defense, working in conjunction with the DOD General Counsel, should collaborate to streamline the waiver approval process, and compile a catalogue both of available waivers and of approved waivers with information about the specific program, the waiver, and the associated rationale. The Secretary of Defense should then make appropriate changes that are within the Department's purview and work with Congress to make recommended changes to constraining legislation.

The effective application of waivers helps inform officials of the utility of certain processes. As waivers accumulate they bring into question the value of the waived process step and present an opportunity to eliminate activities that add little value but may demand significant human, financial, or schedule resources. Systemically adaptable organizations will routinely abandon less valuable activities to increase speed and reduce cost. The application of waivers serves as a useful feedback process for enterprise reengineering. Regulations, policies, and statutes may be streamlined based on waiver usage and outcome.

"... the essence of adaptation involves a keen sensitivity to what should be abandoned—not what should be changed or introduced." –Peter Drucker

The enterprise will benefit from broader awareness of available waivers and how they are being used. Social networking tools have been employed in many communities to create a forum for real time information sharing. A program manager's social network could become a mechanism to share best practices and inspire greater utilization of effective waivers and accelerate the change process.

Implementation Action: The Secretary of Defense direct that the USD (AT&L) and General Counsel **analyze waiver experience data** to identify processes that are frequently waived and are candidates for changing regulations, policies, or statues to eliminate superfluous activities.

Use of waivers during pilot projects. Past performance suggests that full compliance with all existing regulations and guidance, while allowing the maximum period of time for each step to elapse will not result in the changes sought. To accomplish this, the service acquisition executives should challenge the enterprise stakeholders for each pilot project to seek waivers where they are necessary and prudent to maintain the program schedule required to meet the specified operational cadence. It is important to add schedule satisfaction to the individual performance metrics for each member of the functional development teams for these pilots. The DSB offers the following candidate programs for each service: for the Army, Ground Combat Vehicle; for the Air Force, Long-Range Strike/Family of Systems; for the Navy, Littoral Combat Ship Mission Modules. Appendix D offers further discussion on setting up pilot programs.

Align Incentives with Objectives

One important reason that DOD lacks crisp execution of its processes is that incentives—for individuals, organizations, and contractors—do not align with Department objectives or with mission needs. Successful organizations have a vision of excellence in managing toward their objectives, and their senior leadership, and the organizations that they lead, are aligned with the objectives of the whole. These performance objectives then cascade down throughout the organization, and annual metrics are measured for each individual to assure that they are contributing.

In DOD, objectives are not well-aligned, and there is significant challenge with aligning the top leadership, both civilian and military, and the organizations that they lead with the Department as a whole. A culture of performance and accountability must be established and continually advocated by the Secretary of Defense and the Department's leadership—a culture that includes alignment and adaptability.

Table 7-1 lists some of the current incentives that motivate decisions and determine performance in DOD. Even this small list illustrates how the many attempts to improve acquisition, performance, costs, and outcomes in the Department have failed because these motivations are not aligned for success. In contrast, while incomplete, the proposed candidate incentives would work to change the way individuals and organizations are motivated and better align stakeholder incentives with the Department's goals and objectives.

Table 7-1. Align Incentives with Objectives

	Motivations		Candidate Incentives
	Current	Proposed	
Individuals	▪ Compliance-centric ▪ Assignments lead to career growth ▪ Control	▪ Mission focused ▪ Outcomes lead to career growth ▪ Positive impact	▪ Increase performance awards, recognition, prizes ▪ Tailor tenure duration without damage to promotion opportunity ▪ Create incentives to retain senior civilians past normal retirement ▪ Promotion performance reviews include "reach back" to success of previous assignment
Organizations	▪ Resources ▪ Size ▪ Power ▪ "Spend it, or lose it"	▪ Mission focused ▪ Efficiency ▪ Speed	▪ Return 20% in overhead savings to organizations in "colorless" money ▪ Eliminate "pocket veto" by implementing tacit approval if no decision beyond short time window ▪ Involve senior leadership (Service Secretaries) in resolving most pressing operator needs (Secretary's Council) ▪ Align authority with accountability for outcomes
Contractors	▪ Profit ▪ Maintenance of barrier to entry ▪ Cash flow ▪ Change orders	▪ Mission focused ▪ Profit ▪ Cash flow ▪ Lower barrier to entry, e.g., commercial ▪ Continuous innovation	▪ Effective and prolific use of incentive fee ▪ Judicious use of Other Transaction Authority ▪ Government-owned intellectual property at interfaces ▪ Continuous competition for new blocks tied to deployment timelines ▪ Renewals for exceptional performance

For example, the Office of the Secretary of Defense and the military departments should be rewarded for cutting overhead to focus resources on mission need and for improvements in efficiency and speed—motivations that in many cases would run counter to current motivations to manage large financial resources, manage large organizations, and "spend it or lose it." Likewise, incentives for individuals need to become more mission-focused and designed so that top performance leads to career growth vice control and variety of assignment. Incentives should also motivate individuals to leave assignments better than they found them, such that performance of the organization they leave should be factored into their future performance review. Too often one is concerned that it does not "happen on my watch" to the extent that problems are not recognized in a timely fashion. Individual incentives should also be designed to retain individuals with knowledge and skills of value to the Department. Finally, incentives should allow appropriate risk taking, while recognizing that occasional failure is an outcome of appropriate risk taking.

Contractor incentives also must be considered, as they play an important role in the Department's ability to achieve national security objectives. Current contract management practices create many disincentives and incentives counter to Department objectives for these companies, who today are motivated largely by profit, opportunities for change orders, and maintaining barriers to entry. In fact, the excessive bureaucratic and regulatory environment is sufficiently onerous that many commercial companies refuse to do business with the government. The Department must, of course, recognize that the contractor community must operate in a way that satisfies their stakeholders and employees. But it should be possible to establish incentives that serve both the Department and contractor community well—incentives that, for example, are mission-focused, allow for reasonable profit, reward successful contract performance, lower the barrier to entry for commercial firms, and promote continuous innovation.

The DSB urges the Secretary of Defense to task the senior leadership in the offices of the Under Secretaries for Personnel and Readiness and for Acquisition, Technology, and Logistics to institute processes that recognize incentives across the Department's organization and personnel, as well as those of the contractor community, and ensure that actions are taken to better align stakeholder incentives with DOD goals.

Implementation Action: Department leadership recognize the incentives that are driving organizational and personal performance and take actions that **better align incentives with DOD national security objectives** as a whole and their impact on specific missions. Conduct meaningful annual performance reviews at every level and take appropriate actions based on achieving performance objectives.

- Secretary of Defense and Chairman, Joint Chiefs of Staff make visible the fact that they are establishing annual performance goals for their direct reports and the organizations that they lead.
- Pick a small number of important programs/activities as pilots:
  - Tabulate key incentives now driving their outcomes.
  - Assess whether those incentives are producing the intended results.
  - Revise incentives as necessary.
  - Use these case studies to make enterprise-wide changes.

Summary of Recommendations

Take explicit steps to instill adaptability as a core value and shift DOD's culture from one of risk aversion to one that emphasizes outcomes, risk management, and efficiencies in how the Department operates.

- Secretary of Defense establish a **Secretary's Council**, comprised of the Service secretaries, to ensure that the vast array of enterprise resources that they command are responsive to the needs of the theater on a joint basis. During times of conflict, the council ensures that requests for supplemental funding and reprogramming of existing funds address the most significant shortfalls identified by the combatant commanders.
  The Secretary's Council recognizes that increased agility is required during times of "hot" war and models the value of leveraging all resources to achieve a shared mission outcome.
- The Secretary of Defense direct that the USD (AT&L) and General Counsel **analyze waiver experience data** to identify processes that are frequently waived and are candidates for changing regulations, policies, or statues to eliminate superfluous activities.
- The Department leadership recognize the incentives that are driving organizational and personal performance and take actions that **better align those incentives with DOD national security objectives** as a whole and

their impact on specific missions. Conduct meaningful annual performance reviews at every level and take appropriate actions based on achieving performance objectives.

In Conclusion

The DSB believes that the Department of Defense has the ability to become a more adaptable organization. But it is a process that will require actions and leadership across the entire enterprise. The recommendations in this report identify the most promising areas on which the Department should focus:

- Aligning enterprise functions to support mission objectives.
- Balancing intelligence resources to address requirements for both hot wars and evolving regions and concerns of future importance.
- Preparing for degraded operations by institutionalizing the use of realistic exercises and red/blue teaming to prepare for uncertain conditions.
- Enhancing the adaptability of the enterprise workforce by broadening awareness and access to the full spectrum of available skills and talent.
- Changing the culture to instill adaptability as a core value, emphasizing outcomes, risk management, and efficiencies.

The aim of the recommendations presented in this report is to increase adaptability in the Department of Defense in order to improve mission effectiveness. We believe that in today's evolving and challenging security environment, the ability to adapt will be essential to success. Further, changes proposed throughout this report not only will dramatically improve mission effectiveness in DOD but also will have the potential to lead to efficiencies and cost savings. We believe that such changes are within the Department's reach and that the actions identified in this report are important first steps.

Terms of Reference

THE UNDER SECRETARY OF DEFENSE
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ACQUISITION,
TECHNOLOGY
AND LOGISTICS

APR 1 2 2010

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board (DSB) 2010 Summer Study on Enhancing Adaptability of our Military Forces

The first decade of the 21st century continues to demonstrate the need for adaptable military forces. Initial efforts in Operation ENDURING FREEDOM successfully employed the USS Kitty Hawk (CV-63) stripped of its air wing and used as an afloat forward staging base for U.S. special forces. Special operations forces operating on horseback employed precision-guided munitions from legacy B-52 and B-1 aircraft in air strikes to great effect. However, these adaptations and the many others arriving from operations in Iraq, Afghanistan, and elsewhere do not yet reflect widespread ability of U.S. forces to deftly transition from one challenge to the next. Adaptability must be a key determinant of what the Department buys, how it trains and develops personnel, how it develops intelligence, and how it operates. Too often, force adaptability relies on a few innovative individuals who, in the heat of a crisis, create an inefficient but effective work-around to accomplish the mission. While we should sustain and encourage such individual innovation, we need to examine what the DoD can do more broadly to enhance both the degree and the cycle time of adaptation.

The Nation's military must improve and enhance the adaptability of our forces and force structure to meet the challenges of the 21st century. The Summer Study should establish defining metrics (e.g., degree of adaptation, cycle time) and identify fundamental attributes of an architecture to enhance adaptability. It should begin by conducting a thorough look historically at the successful adaptations we have made. It should identify successful examples of adaptation, both commercial and non-commercial, and what made them successful and also unsuccessful examples and the factors which contributed to unsuccessful adaptation. The Summer Study should also look at any "commercial" examples of the adaptation of a capability or technology to something beyond its original intent. This should include examining how any such commercial examples were quickly brought to market. A partial list of areas for consideration includes:

- Personnel development – assess mechanisms to develop and retain the flexible and agile military and civilian workforce capable of rapidly adapting to 21st century challenges:
    - Retaining relevant knowledge from the departing workforce;
    - Capturing and effectively incorporating the operational experience from the current conflicts;

- Developing new recruitment sources, especially in emerging technologies, cultures and languages of interest, maintaining technical competence, and identifying cost-effective retention mechanisms, etc.

- Training – assess techniques to rapidly and effectively train and educate the current and future workforce;

- Intelligence – enhance planning by increasing emphasis on identifying regions where instability and developing crises may impact our national interests. Adapt intelligence analysis and assessments to support changing mission needs and develop traditional and non-traditional intelligence systems that can be easily integrated to share and distribute information (e.g., U.S. and allied/coalition forces, inter- and intra-agency, and relevant non-governmental organizations);

- Requirements – give explicit consideration to adaptability in Analyses of Alternatives, giving preference to capabilities that are inherently adaptable or include provisions to enhance adaptability. Exploit commercial developments of systems and services that can be responsive to mission needs;

- Acquisition – tailor acquisition processes to acquire capability as new challenges are identified, extend legacy capability when cost effective, and maintain current capability where needed. Apply systems engineering and open architecture approaches to establish standard interfaces to enhance our ability to connect and combine systems (e.g., ground control systems and processors, and their connections to space systems, UAVs, robotics, and sensors). Assess approaches to preplan for adaptation of major platforms, sensors, command and control (C2), and munitions as an integral element of development planning, and demonstrate critical enablers;

- Degraded operations – plan for adapting to degradations in our networks, sensors, information and C2 systems in the presence of cyber attacks on military systems and the critical supporting infrastructure on which we depend;

- Rapid transition of the force and support systems to fight the wars that were not planned for.

There is ample precedent for the DSB Summer Studies serving an agenda-setting function, to very good effect. One or a few of these areas might yield actionable recommendations during the Summer Study proper; others may be identified for more in-depth review later by specific task forces (TFs).

This TF will be sponsored by me as the Under Secretary of Defense for Acquisition, Technology and Logistics. Dr. William LaPlante and Mr. Al Grasso will co-chair the Summer Study. Mr. Paul Eremenko will serve as Executive Secretary. Lieutenant Colonel Karen Walters, USA, will serve as the DSB Secretariat Representative.

The TF will operate in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, the "DoD Federal Advisory Committee Management program." It is not anticipated that this TF will need to go into any "particular matters" within the meaning of title 18, United States Code, section 208, nor will it cause any member to be placed in the position of action as a procurement official.

Ashton B. Carter

Study Membership

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Executive Secretary	
Dr. Paul Eremenko	Defense Advanced Research Projects Agency
Senior Review Group	
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Mr. Greg Hulcher	Office of the Secretary of Defense
Col Greg Zehner, USA	Joint Staff J8
CDR Christopher Nash, USN	Joint Staff J8
DSB Representative	
LTC Karen Walters, USA	OUSD (AT&L)
Panel 5. Degraded Operations	
Chairs	
Dr. Eric Evans	MIT Lincoln Laboratory
General James McCarthy, USAF (ret.)	U.S. Air Force Academy

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Dr. John Dowdle	Charles Stark Draper Laboratory
Dr. William Howard	Private Consultant
Dr. Miriam John	Private Consultant
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Ms. Stephanie Simonich	Strategic Analysis, Inc.
Mr. Ted Stump	Strategic Analysis, Inc.
Ms. Vanessa Todd	Strategic Analysis, Inc.

Presentations to the Study

NAME	TOPIC
Plenary Meetings	
March 15–16, 2010	
Ryan Ehrler Fort Bragg	War Fighter Adaptability Perspectives
LTC Sean Feeley U.S. Special Operations Command, Irregular Warfare Office	War Fighter Adaptability Perspectives
Conrad Orloff John Hopkins University, Applied Physics Laboratory	War Fighter Adaptability Perspectives
CDR James Joyner Defense Advanced Research Projects Agency, Adaptability Execution Office	War Fighter Adaptability Perspectives
Ryan Ehrler, LTC Sean Feeley, Conrad Orloff, CDR James Joyner	Panel on Area of Responsibility Experiences
Drs. Richard Games and Greg Crawford MITRE	Adapting Ground Moving Target Indicator and Multi-INT
Dr. Pete Rustan National Reconnaissance Office (NRO)	NRO Support to Military Operations
Colonel Thomas Murphy Center for Army Lessons Learned	Adaptability Lessons Learned
Robert Harms and Jeff White National Security Agency	Real Time-Regional Gateway, An Example of Adapting to Tactical Requirements
Lieutenant General Rick Lynch Commanding General, U.S. Army Installation Management Command	War Fighter Adaptability Perspectives
Mr. Lloyd Rowland Deputy Director, National Geospatial-Intelligence Agency (NGA)	NGA Opening Remarks
Brigadier General Peter Zwack Director, Military Support, NGA	NGA Support to Military Operations
April 8, 2010	
Ron Jost Office of the Assistant Secretary of Defense for Networks and Information Integration	Joint Tactical Radio System
Paul Eremenko Defense Advanced Research Projects Agency	System F6
Williamson Murray Institute for Defense Analysis	Historical Perspective on Adaptability

NAME	TOPIC
June 8, 2010	
Robert Stein Private Consultant, Co-chair Remote Strike Task Force	Findings and Recommendations of the Remote Strike Task Force
COL Bryan McVeigh Project Manager Ground Combat Vehicle	Ground Combat Vehicle – Overview
Roy Evans, Jr. MITRE	Family of Systems – Prior Work
Greg Hulcher Office of the Under Secretary of Defense for Acquisition, Technology and Logistics	Family of Systems – Current Studies
Gregory Glaros President, Synexxus	Real Options in Defense
July 7, 2010	
Paul Eremenko DARPA Tactical Technology Office	DARPA "Adaptive Make for Ground Combat Vehicle"
Bryan Clark OPNAV	Navy's Strategic Vision of Adaptability
Daniel E. Hastings MIT Dean of Undergraduate Education	Analytical Methods and Metrics for Adaptability
Michael A. Cusumano MIT Sloan School of Management	Adaptability in the Commercial World
Panel 1. Integration	
April 9, 2010	
Mr. James Thomas Center for Strategic and Budgetary Assessments	Observations on Enhancing Adaptability of Military Forces
CAPT Wayne Porter, U.S. Navy Special Assistant for Strategy, Office of the Chairman of the Joint Chiefs	Observations on Enhancing Adaptability of Military Forces
May 11, 2010	
LtGen Jay Paxton J3/J5	Observations on Enhancing Adaptability of Military Forces
MG Jim Hunt I Corps	Observations on Enhancing Adaptability of Military Forces
Mr. Andrew May Office of Net Assessment	Observations on Enhancing Adaptability of Military Forces

NAME	TOPIC
June 1–2, 2010	
GEN James Mattis Commander, U.S. Joint Forces Command	Observations on Enhancing Adaptability of Military Forces
CAPT Bob Lineberry Chief of Staff, U.S. Navy, Navy Warfare Development Command	Observations on Enhancing Adaptability of Military Forces
Mr. Rickey Smith and Mr Ed Mazzanti U.S. Army Training and Doctrine Command	Observations on Enhancing Adaptability of Military Forces
COL Ron Sanders, USAF Strategy Concepts and Doctrine Division, U.S. Air Force Air Combat Command	Observations on Enhancing Adaptability of Military Forces
June 9, 2010	
Dr. Lawrence Burns Corporate Vice President of R&D and Strategic Planning, General Motors (Ret.)	On Adaptation in a Large, Structured Organization
Dr. Bryan Tipton and Dr Curtis Davis MIT Lincoln Laboratory	Adaptability in ISR systems
Ms. Tara Lemmey CEO, LENS Ventures	Innovation and adaptation
July 8, 2010	
CAPT Mike Ford Chief, Requirements Management Division, J-8	The JCIDS "IT Box"
Mr. Tim Harp Deputy Assistant Secretary of Defense (C3IRS & IT Acquisition)	IT and Enhancing Adaptability of Military Forces
Mr. Daniel Kaufman Director, Information Processing Techniques Office, DARPA	RealWorld and Other Tools for Enhancing Adaptability of Military Forces
Mr. James Utterback Professor of Management and Innovation, Engineering Systems Division, MIT	Management and Innovation
Dr. William Mark Vice President, Information and Computing Sciences Division, SRI Dr. Richard Murray Professor of Control & Dynamical Systems and Bioengineering, Caltech	Information Science and Technology Study on Metrics for System Adaptability

NAME	TOPIC
Panel 2. Human Resources	
April 9, 2010	
Dr. Waldo Freeman & Dr. William Burns Institute for Defense Analysis	Adaptability Training
Dr. Michael Rumsey U.S. Army Research Institute	Testing for Adaptability
Dr. Robert Sternberg Tufts University	Successful Intelligence
May 11, 2010	
Dr. Paul Tanenbaum Director, Survivability/Lethality Analysis Directorate U.S. Army Research Laboratory	Real-Time Feedback from Battlefield to Research
Mr. Paul Aswell Deputy Chief of Staff, G-1 Headquarters, Department of the Army	Army Personnel Program
Mr. Gregory Conover Institute for Defense Analyses	Broadening Irregular Warfare Capabilities: Recommendations to Improve Fires in Distributed Operations
Ms. Gail McGinn Deputy Under Secretary of Defense for Plans	DOD Language Program
June 9, 2010	
RADM Dan Holloway Director, Manpower, Personnel, Training and Education Policy Division (N13)	Navy Personnel Adaptability
Brig Gen Sharon K.G. Dunbar Director, Force Management Policy	USAF Personnel Adaptability
Ms. Marilee Fitzgerald Acting Deputy Under Secretary of Defense for Civilian Personnel Policy	Civilian Expeditionary Workforce
COL Michael (Mick) Ryan Australian Army	Adaptability in Australian Army
Dr. Richard Hughes USAFA Transformation Chair U.S. Air Force Academy	The U.S. Air Force Academy Outcomes as "Targets" of Development, and Implications for Adaptability & The Relationship Between Individual and Organizational Adaptability
Mr. M.F. Applegate Director, Manpower Plans and Policy Division (M&RA)	USMC Personnel Adaptability

NAME	TOPIC
July 8, 2010	
Mr. Joe Angelo Defense Safety Oversight Council	DOD Safety Initiative
Dr. Derek Leebaert MAP AG, Georgetown University	Management Assessment
Dr. David Alderton Navy Personnel Research, Studies & Technology, Bureau of Naval Personnel	Navy Testing
COL Michael Meese Office of Economic and Manpower Analysis, Department of Social Sciences, United States Military Academy	Army Officer Adaptability
Dr. David Graham Institute for Defense Analyses	Incentives for Deployment
Dr. William Knowlton Industrial College of the Armed Forces, National Defense University	National Defense University Executive Assessment
Panel 3. Intelligence	
April 30, 2010	
Mr. Jeff Rapp Vice Deputy for Analysis, Defense Intelligence Agency	Defense Intelligence Agency Analytical Approach and Capabilities
Mr. Wilson Cook Dean of the Sherman Kent School, Central Intelligence Agency	Central Intelligence Agency Analytical Approach and Capabilities
Mr. Bruce Pease Sherman Kent School, Central Intelligence Agency	Analytical Community
Mr. Kevin O'Connell President and CEO, Innovative Analytics and Training and Adjunct Professor, Security Studies Program at Georgetown University	State of the Intelligence Analytical Community
Mr. Russ Travers Deputy Director for Information Sharing and Knowledge Development, National Counter Terrorism Center	National Counter Terrorism Center
Mr. James Buchanan Deputy Assistant Secretary of State for Analysis	State of the Analytical Community, Post 9/11
May 14, 2010	
MG Michael Flynn Chief, CJ2, International Security Assistance Force	State of the Combat Support Agency and Intelligence Community Analytical Community
Mr. Peter Lavoy Deputy Director of National Intelligence for Analysis	Intelligence "Coverage" Beyond the Two Conflicts

NAME	TOPIC
June 24, 2010	
Dr. MacDougall Defense Intelligence Agency	Defense Intelligence Agency /DT Support to the Two Wars Counter-IED Effort, Forensics, and Biometrics
Mr. Bane National Media Exploitation Center	National Media Exploitation Center – Support to the Two Wars
Mr. Butler Assistant Deputy Director of National Intelligence for Open Source	Open Source Analytic Tradecraft
Mr. Naquin Director, Open Source Center	Open Source Center
Mr. Frank Strickland Edge Methods	Application of Intelligence to Operations
Panel 4. Adaptive Capabilities	
April 9, 2010	
Earl C. Wyatt Director, Rapid Fielding Office of the Director, Defense Research and Engineering (DDR&E)	DDR&E Perspectives on Rapid Fielding
May 6, 2010	
Mr. Jim Simpson Vice President for Business Development, Space, and Intelligence Systems, Boeing Corp.	Commercial vs. Government Space Business
COL Kirk F. Vollmecke Chief, Capabilities and Acquisition Division, J-8/Joint Staff	Changes to DOD Requirements and Acquisition
CAPT Michael Ford Joint Staff / J-8 Chief , Requirements Management Division	JUONS, DCRs, and the IT Box
Mr. Bill Johnson	Acoustic Rapid COTS Insertion (ARCI)
May 7, 2010	
Dr. David Markowitz HQDA G3, DAMO-CI	Service Urgent Operational Needs – Army
Colonel Wayne McGee AF/A5RP	U.S. Air Force Urgent Operational Need Process
Captain Brad Martin, USN Branch Head, Joint Requirements and Acquisition Assessments Division, Navy Staff	Navy Urgent Needs Process
Mr. Richard Webster MCCDC MAGTF Integration Division	Service Urgent Operational Needs – USMC
Dr. Bobby Junker ONR C4ISR Department	Scalable Modular Open System Approach

NAME	TOPIC
June 7, 2010	
Mr. Jeff Parsons Army Contracting Command	Rapid/Expeditionary Contracting
Mr. Bob Stein Private Consultant and Co-chair of the Global Prompt Strike Task Force	DSB Global Prompt Strike Report
Mr. Jerome Lynes Chief, Joint Education & Doctrine Division Joint Staff J7	Joint/Service Doctrine and TTPs, CONOPS
Colonel Kevin Benson U.S. Army (Ret.)	Warfighting Tactics, Techniques, and Procedures and Concepts of Operation Adaptability within Doctrine Timelines
July 8, 2010	
LTC Paul Olsen SA DCS G-3/5/7	Reflections on 'Building Great Engineers'
Dr. Donna Senft Air Force Research Lab's Space Directorate	Engineering Adaptability into Spacecraft Acquisition: Space Plug-and-Play
Dr. James Utterback Professor of Management and Innovation, Engineering Systems Division, Massachusetts Institute of Technology	Innovation, Resilience and Adaptability in U.S. Firms and Industries
MGySgt Scott Martin United States Marine Corps	Tactics, Techniques and Procedures
August 5, 2010	
Mr. James F. Gibson G3, FAST, RDECOM	Army FAST Program
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April 27, 2010	
Lt Col David Thirtyacre, USAF U.S. Air Force Warfare Center	USAF Warfare Center Degraded Operations Test/Tactics/Training
CAPT Sandra Schiavo, USN Assessment Division, Chief of Naval Operations (N81F)	Impact of Satellite Vulnerability on Navy Operations
Mr. Patrick McVay, SES J7 Director, Joint Exercises and Training	Global Thunder/Lightening Exercises
May 19, 2010	
Mr. Jeffery Bearor, SES Executive Deputy to Training and Education Command	USMC Training and Education
Col Frank Kuska, USAF Chief, Joint Exercise and Interoperability Division, U.S. Special Operations Command	SOCOM Training and Operations
COL John Harding, USA Director, Combat Training Center Directorate	Building Adaptive Leaders and Units at the Combat Training Centers

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May 20, 2010	
CSM Michael Cortes, USA Army Asymmetric Warfare Group	Training for Asymmetric Warfare
June 9, 2010	
Lt Col Michael Zuber, USAF U.S. Transportation Command	Cyber Threats and Responses
Dr. Miriam John and Mr. Bob Stein 2008 DSB Summer Study Chairs	Capability Surprise
BG John Davis, USA Deputy Commander, Joint Task Force-Global Network Operations	Joint Staff Perspectives on Network Operations in a Degraded Environment
June 10, 2010	
Staff, Defense Intelligence Agency	Cyber Threats
July 1, 2010	
Gen James Mattis, USMC Commander, U.S. Joint Forces Command	U.S. Joint Forces Command Approach to Degraded Operations
Dr. Ted Gold 2003 Task Force Co-Chair	The Role and Status of DOD Red Teaming Activities
Dr. Janet Fender, SES Chief Scientist, Air Combat Command; Col Lawrence Averbeck, USAF Air Combat Command	A Day Without Space
Mr. Marshall Brenizer Assistant Leader, Space Systems Analysis Group, MIT Lincoln Laboratory; Maj Daniel St. Pierre, USAF Air Force Rapid Capabilities Office	Air Force Space Mission Assurance
July 2, 2010	
Col Douglas Mason, USMC U.S. Pacific Command	Terminal Fury 2010 Exercise

Glossary

AIM	Assessment of Individual Motivation
AIP	[Navy] Assignment Incentive Pay [program]
AMD	advanced micro devices
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AoA	analysis of alternatives
ARCI	Acoustic Rapid COTS Insertion [program]
ARFORGEN	Army Force Generation [process]
ASD (RA)	Assistant Secretary of Defense for Reserve Affairs
ASVAB	Armed Services Vocational Aptitude Battery
ASW	anti-submarine warfare
AWACS	Airborne Warning and Control System
AWG	[Army] Asymmetric Warfare Group
C3I	command, control, communications, and intelligence
C3ISR	command, control, communications, intelligence, surveillance, and reconnaissance
C4I	command, control, communications, computers, and intelligence
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
C5I	command, control, communications, computers, collaboration, and intelligence
CAD	computer-aided design
CAOC	Combined Air Operations Center
CDD	Capability Development Document
CEO	Chief Executive Officer
CIA	Central Intelligence Agency
CJ2	Combined Joint Staff Branch for Intelligence
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CONOPS	concept of operation
COTS	commercial off-the-shelf
CSH	Combat Support Hospital
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DIA	Defense Intelligence Agency

DDR&E	Director, Defense Research and Engineering
DIOSPO	Defense Open Source Program Office
DLIFLC	Defense Language Institute Foreign Language Center
DNI	Director of National Intelligence
DOD	Department of Defense
DRAM	dynamic random access memory
DSB	Defense Science Board
FAO	foreign area officer
FBCB2	Force XXI Battle Command Brigade and Below
FCS	Future Combat System
FoS	Family of Systems
GAO	U.S. Government Accountability Office
GED	General Education Development
GM	General Motors
GPS	Global Positioning System
HASC O&I	House Armed Services Committee Subcommittee on Oversight & Investigations
HMMWV	high mobility multipurpose wheeled vehicle
HQE	Highly Qualified Expert [authority]
IC	intelligence community
IDA	Institute for Defense Analyses
IED	improvised explosive device
IOC	initial operational capability
IWS	Integrated Warfare Systems
IPA	Intergovernmental Personnel Act
IPT	integrated product team
IPTV	Internet Protocol television
ISR	intelligence, surveillance, and reconnaissance
IT	information technology
JCIDS	Joint Capabilities Integration and Development System
JFCOM	U.S. Joint Forces Command
JIEDDO	Joint Improvised Explosive Device Defeat Organization
JROC	Joint Requirements Oversight Council
JTIDS	Joint Tactical Information Distribution System
JUON	joint urgent operational need
KPPs	key performance parameters

LAN	local area network
LAV	Light Armored Vehicle
LCS	Littoral Combat Ship
LRS	long-range strike
MCM	mine countermeasures
MDA	Missile Defense Agency
MHAT	Mental Health Advisory Team
MRAP	Mine Resistant Ambush Protected [vehicle program]
MSIP	Multinational Staged Improvement Program
NASIC	National Air and Space Intelligence Center
NATO	North Atlantic Treaty Organization
NAVSEA	Naval Sea Systems Command
NCAPS	Navy Computer Adaptive Personality Scales
NGA	National Geospatial-Intelligence Agency
NIPF	National Intelligence Priorities Framework
NLSC	National Language Service Corps
NMEC	National Media Exploitation Center
NSA	National Security Agency
NSLI	National Security Language Initiative
NRO	National Reconnaissance Office
ODNI	Office of the Director of National Intelligence
OODA	observe, orient, decide, act
OSD	Office of the Secretary of Defense
OSINT	open source intelligence
OSW	Open Source Skunk Works
OT&E	operational test and evaluation
OUSD (AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology and Logistics
PACOM	U.S. Pacific Command
PC	personal computer
PEO	program executive office
PEO IWS	Program Executive Office for Integrated Warfare Systems [Navy]
PMO	program management office
PNT	precision, navigation, and timing
POM	program objective memorandum
PTSD	post traumatic stress disorder

QDR	Quadrennial Defense Review
R&D	research and development
RASER	Rapid Analytical Support and Expeditionary Response
RBI	Rational Biodata Inventory
RFP	request for proposal
ROTC	Reserve Officer Training Corp
SAF/A-8	Air Staff/Strategic Plans and Programs
SAF/AQ	Secretary of the Air Force/Acquisition
SHARP	Summer Hard Targets Program
SOCOM	U.S. Special Operations Command
SOF	Special Operations Forces
SPO	system program office
SRAM	static random access memory
SSA	space situational awareness
SSBN	ballistic missile submarine
STRATCOM	U.S. Strategic Command
SWAP	size, weight, and power
TAP	Test of Adaptable Personality
TAPAS	Tailored Adaptive Personality Assessment System
TS/NOFORN	Top Secret/Not Releasable to Foreign Nationals
TTPs	tactics, techniques, and procedures
TUAV	Tactical Unmanned Aerial Vehicle
UAV	Unmanned Aerial Vehicle
UON	urgent operational need
USAF	United States Air Force
USAID	United States Agency for International Development
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
USD (I)	Under Secretary of Defense for Intelligence
USD (P&R)	Under Secretary of Defense for Personnel and Readiness
USMC	United States Marine Corps
USSOCOM	U.S. Special Operations Command
WMD	weapons of mass destruction

Report of the
Defense Science Board
2010 Summer Study on

Enhancing Adaptability of U.S. Military Forces

Part B. Appendices

January 2011

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB).

The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense. The Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces completed its information-gathering in August 2010.

This report is unclassified and cleared for public release.

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301–3140

DEFENSE SCIENCE BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS

SUBJECT: Final Report of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces

I am pleased to forward the final report of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces. This report offers important recommendations for how the Department of Defense can better face the rapidly changing security environment of the 21st century by increasing its adaptability.

The study used business and government case studies to derive its definition of adaptability which identified the key elements as the ability and willingness to anticipate the need for change, to prepare for that change, and to implement changes in a timely and effective manner in response to the surrounding environment. The study identified a strategy to promote the elements of adaptability in DOD, with an ultimate goal of improving mission effectiveness. The key elements of this strategy are:

- align enterprise functions to support mission outcomes
- reduce uncertainty through better global awareness
- prepare for degraded operations
- enhance the adaptability of the workforce
- change the culture

In the judgment of the Defense Science Board, the Department can achieve greater adaptability across the enterprise—moving beyond the cultural, organizational, and regulatory barriers that exist.

I endorse all of the study's recommendations and encourage you to forward the report to the Secretary of Defense.

Paul S Kaminski

Dr. Paul Kaminski
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301–3140

DEFENSE SCIENCE BOARD

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board 2010 Summer Study on Enhancing Adaptability of U.S. Military Forces

Today's military forces face an increased level of operational uncertainty and must be ready to adapt rapidly. Adversaries evolve in days, weeks, or months, and U.S. forces must be able to adapt in kind—not in decades, as is the timeline of many current processes. However, DOD's lengthy preparation cycles and associated enterprise culture hinder the pace of response that is needed.

This study was charged to help DOD make adaptability a core value—a part of the culture of the enterprise, both its processes and people. The Defense Science Board has identified what it believes are the key elements of a strategy to promote adaptability within the Department of Defense.

- **Align enterprise functions to support mission outcomes.** Couple enterprise functions to mission outcomes by tying deliverables with operational timelines.
- **Reduce uncertainty through better global awareness.** Persistent and deployable teams drawing from all sources, including and especially, open source, rapidly provide contextual understanding of potential global "hot spots" to improve preparedness and agility of response.
- **Prepare for degraded operations.** Institutionalize the use of realistic exercises and red/blue teaming to prepare for uncertain conditions, beginning with two areas of critical importance to nearly all aspects of war fighting—cyber and space.
- **Enhance adaptability of the enterprise workforce.** Broaden awareness and access to the full spectrum of available skills and talent.
- **Change the culture.** Move from a risk-averse to risk-managed approach by employing waiver authority as needed to accomplish mission objectives and conduct follow on analysis of waiver usage to identify and eliminate unnecessary or restrictive processes. Establish a Secretary's Council to resolve problems in meeting the needs of the combatant commanders promptly by using existing resources in new and different ways. Align incentives with objectives and reward adaptability.

In today's evolving and challenging security environment, the ability to adapt will be essential to improving mission effectiveness, with the potential to lead to efficiencies and cost savings. It is the judgment of the Defense Science Board that the Department can and must move beyond cultural, organizational, and regulatory barriers and achieve greater adaptability across the enterprise. The recommendations in this report are important first steps.

Mr. Al Grasso
Co-Chair

Dr. William LaPlante
Co-Chair

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Appendix A. Case Studies

The following are summaries of several case studies considered by the study to inform their work. The cases were selected from both successful and unsuccessful adaptations across both commercial and defense organizations. They are presented here in alphabetical order.

Commercial Examples

Amazon

Amazon is an American-based multinational electronic commerce company. Headquartered in Seattle, Washington, it is America's largest online retailer, with nearly three times the Internet sales revenue of the runner up, Staples, Inc., as of January 2010. Company founder, Jeff Bezos, named the company "Amazon" after the world's largest river. Since 2000, Amazon's logotype is an arrow leading from A to Z, representing customer satisfaction (as it forms a smile); a goal was to have every product in the alphabet.[1]

History

Amazon.com, Inc. was founded in 1994 and launched online in 1995 as Cadabra.com. The company began as an online bookstore.[2] While the largest brick-and-mortar bookstores and mail-order catalogs for books might offer 200,000 titles, an online bookstore could offer more. Amazon also was quick to diversify, selling DVDs, CDs, MP3 downloads, computer software, video games, electronics, apparel, furniture, food, and toys.

Amazon's initial business plan was unusual: the company did not expect a profit for four to five years. Its "slow" growth provoked stockholder complaints that the company was not reaching profitability fast enough. When the dot-com bubble burst, and many e-companies went out of business, Amazon persevered, and finally turned

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1. "amazon.com Introduces New Logo; New Design Communicates Customer Satisfaction and A-to-Z Selection." http://phx.corporate-ir.net/phoenix.zhtml?c=97664&p=irol-newsArticle&ID=70550&highlight=
2. *NY Times*, July 10, 2005, "A Retail Revolution Turns 10." http://www.nytimes.com/2005/07/10/business/yourmoney/10amazon.html?ei=5090&en=c805d53acf76f2b3&ex=1278648000&partner=rssuserland&emc=rss&pagewanted=all

its first profit in the fourth quarter of 2001: $5 million or 1¢ per share, on revenues of more than $1 billion, but the modest profit was important in demonstrating the business model could be profitable.

Differentiating Characteristics

Amazon's unique business model and willingness to extend and change as others (*e.g.*, Borders) "catch-up" played a role in surviving the dot.com bust. They established a culture of innovation in "big things" (new products, *e.g.*, e-book readers) and "small things" (internal process improvements). Amazon continues to maintain a customer/market focus. As the company's CEO said, "Companies get skills focused, instead of customer needs focused. When [companies] think about extending their business into some new area, the first question is 'why should we do that—we don't have any skills in that area.' That approach puts a finite lifetime on a company, because the world changes, and what used to be cutting-edge skills have turned into something your customers may not need anymore. A much more stable strategy is to start with 'what do my customers need?' Then do an inventory of the gaps in your skills. Kindle is a great example. If we set our strategy by what our skills happen to be rather than by what our customers need, we never would have done it. We had to go out and hire people who know how to build hardware devices and create a whole new competency for the company."[3]

Apple

Apple Inc. is an American multinational corporation that designs and markets consumer electronics, computer software, and personal computers. The company's best-known hardware products include the Macintosh computers, the iPod, the iPhone and the iPad. Apple software includes the Mac OS X operating system; the iTunes media browser; the iLife suite of multimedia and creativity software; the iWork suite of productivity software; Aperture, a professional photography package; Final Cut Studio, a suite of professional audio and film-industry software products; Logic Studio, a suite of music production tools; and its iOS Mobile Operating System. As of August 2010, the

3. *Bloomberg Business Week*, April 17, 2008.
http://www.businessweek.com/magazine/content/08_17/b4081064880218_page_2.htm

company operates 300 retail stores[4] in ten countries[5] and an online store where hardware and software products are sold.

History

Established on April 1, 1976 in Cupertino, California, and incorporated January 3, 1977,[6] the company was named Apple Computer, Inc., for its first 30 years. On January 9, 2007,[7] the word "Computer" was removed from the name to reflect the company's ongoing expansion into the consumer electronics market in addition to its traditional focus on personal computers.[8] As of September 26, 2009, Apple had 34,300 full time employees and 2,500 temporary full time employees worldwide[9] and had worldwide annual sales of $42.91 billion in its fiscal year ending September 26, 2009.[10]

Differentiating Characteristics

Apple has a well developed culture of innovation that pursues a regimented approach for innovation focused on future challenges. This approach creates cross-functional teams with responsibility and authority. The "process of learning what customers really value and then using all the resources you have available to deliver complete, lovable products, services, and experiences throughout the entire life cycle of the customer. This starts with a commitment to thoroughly understand your customers- their problems, needs, and desires- and not compromising until you've delivered the products and services that earn their love and respect."[11] Apple has

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4. "Macworld UK – Grand opening of Apple's 300th retail store brings Covent Garden to a standstill," *Macworld UK*. Accessed August 30, 2010. http://www.macworld.co.uk/digitallifestyle/news/index.cfm?olo=rss&NewsID=3234571
5. "Apple Store—Store List," Apple Inc. http://www.apple.com/retail/storelist/
6. "Apple Investor Relations FAQ," Apple Inc. http://phx.corporate-ir.net/phoenix.zhtml?c=107357&p=irol-faq#corpinfo1
7. Form 8-K SEC Filing, January 10, 2007. http://ccbn.10kwizard.com/cgi/convert/pdf/APPLEINC8K.pdf?pdf=1&repo=tenk&ipage=4589126&num=-2&pdf=1&xml=1&cik=320193&odef=8&rid=12&quest=1&dn=2&dn=3
8. John Markoff. "New Mobile Phone Signals Apple's Ambition," *The New York Times,* January 9, 2007. http://www10.nytimes.com/2007/01/09/technology/09cnd-iphone.html
9. Form 10-K SEC Filing, October 27, 2009. phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MTg1OTB8Q2hpbGRJRD0tMXxUeXBlPTM=&t=1
10. "Revised Request Quarterly Income Statement," Apple Inc., January 25, 2010. Accessed January 25, 2010. http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9Mjc1MjN8Q2hpbGRJRD0tMXxUeXBlPTM=&t=1
11. SurveyAnalytics Blog, Enterprise Research Platform. http://blog.surveyanalytics.com/2010/06/09/lovable-innovation-part-1-essential-philosophies-to-deliver-lovable-products-with-lessons-from-apple-to-gm/

adapted to anticipated market challenges for over 30 years and has sustained competitive market advantage.

Boeing

Boeing is a major aerospace and defense corporation, founded by William E. Boeing in Seattle, Washington. Boeing is the largest global aircraft manufacturer by revenue, orders, and deliveries, and the third largest aerospace and defense contractor in the world based on defense-related revenue.[12] Boeing is the largest exporter by value in the United States.[13] Boeing, headquartered in Chicago, Illinois since 2001, is made up of multiple business units: Boeing Commercial Airplanes; Boeing Defense, Space & Security; Engineering, Operations & Technology; Boeing Capital; and Boeing Shared Services Group.

History

Boeing has expanded over the years, merging with McDonnell Douglas in 1997. After several decades of success, Boeing lost ground to Airbus and subsequently lost its position as market leader in 2003. Multiple Boeing projects were pursued and then canceled, notably the Sonic Cruiser, a proposed jetliner that would cut intercontinental travel times by as much as 20 percent, launched in 2001. However, the plane's fate was sealed by the changes in the commercial aviation market following the September 11 attacks and the subsequent weak economy and increase in fuel prices. Subsequently, Boeing streamlined production and turned its attention to a new model, the 787 Dreamliner, using much of the technology developed for the Sonic Cruiser, but in a more conventional aircraft designed for maximum efficiency. The company also launched new variants of its successful 737 and 777 models. The 787 proved to be highly popular choice with airlines, and won a record number of pre-launch orders at a time in which Airbus was seen to be struggling with delays and cost. The 787 has encountered delays in coming to production, with the first flight not occurring until late 2009, more than two years late. Production will be increased to 10 Boeing 787s per month by 2013.[14]

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12. "Defense News Top 100 for 2008," *Defense News*. http://www.defensenews.com/static/features/top100/charts/rank_2008.php?c=FEA&s=T1C
13. "Boeing says it's flying high despite recession," *USA Today*, March 27, 2009. http://www.usatoday.com/money/industries/manufacturing/2009-03-25-boeing-recession_N.htm
14. "Boeing 787 first flight announced," BBC, August 27, 2009. http://news.bbc.co.uk/2/hi/business/8224799.stm

Differentiating Characteristics

Boeing's decision to change focus to a long-range 200-300 seat 787 versus the A380 enabled point-to-point versus hub and spoke travel. Boeing also focused on product innovation, including carbon fiber, advanced electronics, and common interface for General Electric and Rolls-Royce engines. Main U.S. assembly facilities were sold to a holding company and development partners were made responsible for over 70 percent of the aircraft, including research and development (R&D). This transition from "build to print" to "build to performance" has helped Boeing regain growth and order book momentum. It remains unclear in 2010, however, whether this strategy will ultimately be successful.

Cisco

Cisco, an American multinational corporation that designs and sells consumer electronics, networking and communications technology, and services, is headquartered in California, and has more than 65,000 employees and annual revenue of $36.11 billion as of 2009.

History

Len Bosack and Sandy Lerner, a married couple who worked as computer operations staff members at Stanford University, later joined by Richard Troiano, founded Cisco Systems in 1984. For Cisco's first product, Bosack adapted multiple-protocol router software originally written some years before by William Yeager, another Stanford employee. While Cisco was not the first company to develop and sell a router,[15] it was one of the first to sell commercially successful routers supporting multiple network protocols.[16] Several acquired companies have grown into $1 billion+ business units for Cisco, including LAN (local area network) switching, Enterprise Voice over Internet Protocol, and home networking. In March 2000, at the height of the dot-com boom, Cisco was the most valuable company in the world, with a market

15. Interview with Judy Estrin, NerdTV #13.
http://www.pbs.org/cringely/nerdtv/transcripts/013.html Accessed August 30, 2010.
16. "The Evolution of Access Routing," June 14, 2004.
http://newsroom.cisco.com/dlls/2004/hd_061404.html Accessed Aug 30, 2010.

capitalization of more than $500 billion.[17] In July 2009, with a market cap of about $108.03 billion,[18] it is still one of the most valuable companies.[19]

Differentiating Characteristics

Cisco codified an adaptive management approach called "rapid iterative prototyping" and emphasizes early value delivery. Cisco staffs projects with people capable of learning and adapting, and puts less reliance on decision-making tools that assume predictability. This strategy helps Cisco maintain sustained competitive advantage while avoiding three kinds of risks: new and unfamiliar technology, work outside the experience of the project team, and project magnitude. Their bottom line is that small and fast beats large and deliberate.

Cemex

CEMEX is a global building materials and cement production company founded in Mexico in 1906. The company is currently based in Monterrey, Mexico. CEMEX has operations extending around the world, with production facilities in 50 countries in North America, the Caribbean, South America, Europe, Asia, and Africa. CEMEX has grown from a local company to one of the top global companies in the industry with close to 47,000 employees worldwide.

History

CEMEX has a rich history of improving the well-being of those it serves through its efforts to pursue innovative industry solutions and efficiency advancements, and to promote a sustainable future. In 2004, CEMEX received the Wharton Infosys Business Transformation Award for their creative and efficient use of information technology. On March 1, 2005, CEMEX completed its $5.8 billion acquisition of the London-based RMC Group, which made CEMEX the worldwide leader in ready-mix concrete production and increased its exposure to

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17. "Cisco pushes past Microsoft in market value," CBS Marketwatch, March 25, 2000. http://www.marketwatch.com/news/story/cisco-pushes-past-microsoft-market/story.aspx?guid=%7BFA6BADEF-05F2-4169-ADDA-12E9D17C4433%7D Accessed August 30, 2010.
18. "Cisco Systems." http://finance.yahoo.com/q?s=csco&d=t
19. Dan Fost. "Chron 200 Market capitalization," *San Francisco Chronicle*, May 5, 2006. http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2006/05/05/BUC200MARKETCAP.DTL Accessed August 30, 2010.

European markets. With the acquisition, the company expects its annual cement production to increase to 97 million tons, and could see its annual sales grow to $15 billion, just shy of the market leader, Lafarge, which has sales of $17 billion.

Differentiating Characteristics

To decrease turnaround time in its Mexican market, CEMEX equipped most of its fleet of concrete mixing trucks with global positioning satellite locators, allowing dispatchers to arrange the deliveries within a twenty minute window, versus the three hours CEMEX's competitors require. This system—which did not emerge from a central R&D lab but rather from CEMEX's internal innovation efforts—has allowed CEMEX to increase its market share, charge a premium to time-conscious contractors, and reduce costs resulting from unused concrete.[20] Deployed empowered teams have the authority to make important business decisions. The following key ideas have become a part of CEMEX's culture: know the customer's mindset intimately, innovate on how work is done and delivered to the customer, and scour everywhere for good ideas on how to improve.

Ericsson

Ericsson, one of Sweden's largest companies, is a provider of telecommunication and data communication systems, and related services, covering a range of technologies, including mobile networks. Directly and through subsidiaries, it also has a major role in mobile devices, cable television, and IPTV (internet protocol television) systems. Ericsson was also the inventor of Bluetooth. Ericsson has offices and operations in more than 150 countries, with more than 20,000 staff in Sweden, and also significant presences in the United Kingdom, India, Ireland, United States, Finland, China, and Brazil. Ericsson is currently the world's largest mobile telecommunications equipment vendor with a market share of 35 percent.

History

Founded in 1876 as a telegraph equipment repair shop by Lars Magnus Ericsson, the company was incorporated on August 18, 1918. Headquartered in Kista, Stockholm since 2003, Ericsson is considered part of the so-called "Wireless Valley." Since the mid-1990s, Ericsson's extensive presence in Stockholm has helped

20. *Fast Company*, February 28, 2002.
http://www.fastcompany.com/magazine/56/ganders.html

transform the city into a European hub of information technology (IT) research. Throughout the 1990s, Ericsson held a 35-40 percent market share of installed cellular telephone systems. Like most of the telecommunications industry, Ericsson suffered heavy losses after the telecommunications crash in the early 2000s. The expected build up and migration to 3G technology stalled in 2001. Ericsson had to fire tens of thousands of staff worldwide in an attempt to manage the financial situation.

Differentiating Characteristics

Ericsson had a decentralized, sales-oriented culture; multiple leadership turnovers; and differences in strategic direction. A new CEO brought in new people and focused on "operational excellence." This included consolidating functions and challenging traditional culture and approach to R&D. Cost-cutting addressed further staff reductions, de-layering, moving manufacturing to low-cost countries, and cutting sales expenses. These three waves of cost-cutting returned the company to break even and profit by the mid-2000s.

Ford

The Ford Motor Company is an American multinational corporation based in Dearborn Michigan. The automaker was founded by Henry Ford and incorporated on June 16, 1903. Ford is currently the second largest automaker in the United States.[21] and the fourth-largest in the world based on number of vehicles sold annually, and the seventh-ranked overall American-based company in the 2008 *Fortune* 500 list, based on global revenues in 2008 of $146.3 billion.[22]

History

Alan Mulally became the Ford CEO in 2006. "When Mr. Mulally, an engineer by training, arrived from Boeing three and a half years ago, Ford seemed on death's door. It suffered a 12.6 billion loss in 2006, when industry wide car sales were strong."[23] In 2007, Ford fell from second to third in U.S. annual vehicle sales for the first time in 56 years, behind General Motors and Toyota. "But in 2008, Ford became the only U.S. car

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21. "World Motor Vehicle Production," International Organization of Motor Vehicle Manufacturers, 2009. http://oica.net/wp-content/uploads/ranking-2009.pdf Accessed August 3, 2010.
22. *Fortune* 500 list for 2009 (based on 2008 sales). http://money.cnn.com/magazines/fortune/fortune500/2009/snapshots/160.html
23. Paul Ingrassia, "Ford's Renaissance Man," *Wall Street Journal*, February 27, 2010. http://online.wsj.com/article/SB10001424052748704479404575087372469421104.html

company to avoid bankruptcy, and actually posted a $2.7 billion profit."[24] During the automotive crisis, Ford's worldwide unit volume dropped to 4.817 million in 2009 but despite the adverse conditions, Ford ended 2009 with a net profit of $2.7 billion.

Differentiating Characteristics

The Ford strategy reflects vision, execution, and focus on brand and marketplace. This is distinct from General Motor's (GM) past focus on business plans and strategic planning. This consistent focus on a "one Ford" strategy that is communicated at every opportunity illustrates how the work of each internal function translates into sustaining competitive advantage in the marketplace. This strategy also includes effective communication to the customers, investors, and Congress. Culture changes underway at Ford reflect significantly improved alignment of all functional elements.

IBM

IBM is a multinational computer, technology, and IT consulting corporation headquartered in Armonk, New York. IBM is the world's fourth largest technology company and the second most valuable global brand.[25] IBM manufactures and sells computer hardware and software (with a focus on the latter), and offers infrastructure services, hosting services, and consulting services in areas ranging from mainframe computers to nanotechnology.[26] At the end of May 2010, IBM bought the Sterling Commerce Unit from AT&T for about $1.4 billion. This is the second largest acquisition by IBM.

History

The company which became IBM was founded in 1896 as the Tabulating Machine Company[27] by Herman Hollerith. IBM has been well known through most of its recent history as the world's largest computer company and systems integrator.[28] With

24. Paul Ingrassia, 2010.
25. "Top Brands 2009," *Business Week*.
http://bwnt.businessweek.com/interactive_reports/best_global_brands_2009/
26. *Nanotechnology & Nanoscience.*
http://domino.research.ibm.com/comm/research.nsf/pages/r.nanotech.html
27. Martin Campbell-Kelly and William Aspray. *Computer a History of the Information Machine – Second Edition*, Westview Press, p. 37, 2004.
28."IBM challenges partner Cisco," CNET Networks.
http://news.cnet.com/8301-1001_3-10228455-92.html

almost 400,000 employees worldwide, IBM is second largest[29] and the second most profitable[30] information technology and services employer in the world, according to the *Forbes* 2000 list with sales of greater than 100 billion U.S. dollars. IBM holds more patents than any other U.S.-based technology company and has eight research laboratories worldwide.[31] The company has scientists, engineers, consultants, and sales professionals in over 200 countries. IBM has an important history of acquisitions and spin-offs. Among the famous ones, German SAP was founded in 1972 by five former IBM engineers and Chinese Lenovo became world-famous after acquiring IBM's Thinkpad business in 2005.

Differentiating Characteristics

IBM's business was based on designing, making, and selling back-office systems causing IBM to lose business to IT consulting firms focused on the emerging Internet and e-commerce, dropping IBM from second most profitable company in 1990 to significant losses through 1993. To counter this situation IBM began aggressive and massive headcount reductions and a global reorganization to bring the focus back to customers and integrated solutions as "One-IBM." IBM began to explore a new business model that focused on Internet opportunities and was able to make the Internet pervasive with IBM (*e.g.*, e-mail, websites, and e-commerce). IBM was able to migrate from "box" maker to service provider and return to profitability in 1994. By 1998, 25 percent of IBM revenue was Internet-related. Virtually all console gaming systems of the latest generation use microprocessors developed by IBM.[32]

Intel

Intel Corporation is a technology company—the world's largest semiconductor chip maker and a leader in silicon innovation. It is the inventor of the x86 series of micro-processors, found in most personal computers. Intel was founded on July 18, 1968, as Integrated Electronics Corporation and is based in Santa Clara, California.

29. "The Global 2000: Sorted by Market Cap," *Forbes*, April 8, 2009. http://www.forbes.com/lists/2009/18/global-09_The-Global-2000_MktVal.html
30. "The Global 2000: Sorted by Profit," *Forbes*, April 8, 2009. http://www.forbes.com/lists/2009/18/global-09_The-Global-2000_Prof.html
31. "IBM maintains patent lead, moves to increase patent quality," January 10, 2006. http://www.ibm.com/news/us/en/2006/01/2006_01_10.html
32. "IBM joins forces with game companies around the world to accelerate innovation," IBM, March 21, 2006. http://www.ibm.com/industries/media/doc/content/news/pressrelease/1551338111.html

Founded by semiconductor pioneers Robert Noyce and Gordon Moore, and widely associated with the executive leadership and vision of Andrew Grove, Intel combines advanced chip design capability with a leading-edge manufacturing capability. Originally known primarily to engineers and technologists, Intel's "Intel Inside" advertising campaign of the 1990s made the company and its Pentium processor household names.

History

Intel was an early developer of SRAM (static random access memory) and DRAM (dynamic random access memory) chips, and this represented the majority of its business until 1981. While Intel created the first commercial microprocessor chip in 1971, it was not until the success of the personal computer (PC) that this became their primary business. During the 1990s, Intel invested heavily in new microprocessor designs fostering the rapid growth of the PC industry. During this period Intel became the dominant supplier of microprocessors for PCs, and was known for aggressive and sometimes controversial tactics in defense of its market position, particularly against AMD, as well as a struggle with Microsoft, for control over the direction of the PC industry.[33,34] The 2010 rankings of the world's 100 most powerful brands published by Millward Brown Optimor showed the company's brand value at number 48.[35]

Differentiating Characteristics

Intel encourages innovative thought and challenged assumptions at all levels of the corporation and pursues a regimented approach for innovation focused on future challenges. It creates cross-functional teams with responsibility and authority. Intel does four things: it defines its crucial challenge correctly, it puts the right people on the problem, it knocks down the barriers between R&D and manufacturing, and it gives researchers the right mix of autonomy and guidance.[36]

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33. Dan Goodin. "Microsoft's holy war on Java,", CNET News.com, September 23, 1998. http://www.news.com/2009-1001-215854.html. Accessed August 30, 2010.
34. Lea Graham. "USA versus Microsoft: the fourth week," BBC News, December 14, 1998. http://news.bbc.co.uk/1/hi/special_report/1998/04/98/microsoft/215645.stm Accessed August 30, 2010.
35. "Brandz Ranking 2010," Millward Brown Optimor, 2010. http://www.millwardbrown.com/Sites/mbOptimor/Ideas/BrandZTop100/BrandZTop100.aspx. Accessed August 30, 2010.
36. George Anders. "How Intel Puts Innovation Inside," *Fast Company*, February 29, 2002. http://www.fastcompany.com/magazine/56/ganders.html. Accessed August 30, 2010.

Google

Google is a multinational public cloud computing, Internet search, and advertising technologies corporation. Google hosts and develops a number of Internet-based services and products and generates profit primarily from advertising through its AdWords program.[37,38] Google runs over one million servers in data centers around the world,[39] and processes over one billion search requests[40] and twenty petabytes of user-generated data every day.[41,42,43]

History

Google was first incorporated as a privately held company on September 4, 1998, with its initial public offering to follow on August 19, 2004. In 2006, the company moved to their current headquarters in Mountain View, California. Google's rapid growth since its incorporation has triggered a chain of products, acquisitions, and partnerships beyond the company's core search engine. The company offers online productivity software, such as its Gmail e-mail software, and social networking tools. Google's products extend to the desktop as well, with applications such as the web browser Google Chrome, the Picasa photo organization and editing software, and the Google Talk instant messaging application. More notably, Google leads the development of the Android mobile phone operating system.

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37. "Financial Tables," Google Investor Relations. http://investor.google.com/fin_data.html. Accessed August 30, 2010.
38. David A. Vise. "Online Ads Give Google Huge Gain in Profit," *The Washington Post*, October 21, 2005. http://www.washingtonpost.com/wp-dyn/content/article/2005/10/20/AR2005102002058.html. Retrieved February 14, 2010.
39. "Google: one million servers and counting," Pandia Search Engine News, July 2, 2007. http://www.pandia.com/sew/481-gartner.html
40. Eric Kuhn. "Google unveils top political searches of 2009," CNN, December 18, 2009. http://politicalticker.blogs.cnn.com/2009/12/18/google-unveils-top-political-searches-of-2009/.
41. Grzegorz Czajkowski. "Sorting 1PB with MapReduce," Official Google Blog., Google, Inc., November 21, 2008 http://googleblog.blogspot.com/2008/11/sorting-1pb-with-mapreduce.html.
42. Niall Kennedy. "Google processes over 20 petabytes of data per day," January 8, 2008 http://www.niallkennedy.com/blog/2008/01/google-mapreduce-stats.html
43. Erick Schonfeld. "Google Processing 20,000 Terabytes A Day, And Growing," TechCrunch. January 9, 2008 http://techcrunch.com/2008/01/09/google-processing-20000-terabytes-a-day-and-growing/.

Differentiating Characteristics

Roughly half of Google's 10,000 employees—all those involved in product development—work in small teams, with an average of three engineers per team. Speed to market is a key goal and with smaller teams there are fewer meetings and fewer people to convince. Teams practice relentless experimentation, including a part of Google Labs' public website that allows user feedback before roll-out. The bottom line is that the company was designed to be adaptive and feel like a small company, which is why small project teams are a key part of its culture.

McDonald's

McDonald's Corporation is the world's largest chain of hamburger fast food restaurants, serving more than 58 million customers daily.[44] A McDonald's restaurant is operated by a franchisee, an affiliate, or the corporation itself. The corporation's revenues come from the rent, royalties, and fees paid by the franchisees, as well as sales in company-operated restaurants. Revenues in 2010 are up sharply, to nearly $6 billion in the second quarter of 2010.[45]

History

The business began in 1940, with a restaurant opened by brothers Richard and Maurice McDonald in San Bernardino, California. Their introduction of the "Speedee Service System" in 1948 established the principles of the modern fast-food restaurant. The present corporation dates its founding to the opening of a franchised restaurant by Ray Kroc, in Des Plaines, Illinois, on April 15, 1955, the ninth McDonald's restaurant overall. Kroc later purchased the McDonald brothers' equity in the company and led its worldwide expansion, and the company became listed on the public stock markets in 1965.[46]

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44. "McDonald's posts sizzling 80% profit rise in 2008," *Breitbart*, January 26, 2009. http://www.breitbart.com/article.php?id=CNG.aec4920fe8094fdd0baaeab2ed126bf1.741&show_article=1 Accessed August 30, 2010.
45. "McDonald's Profit Rises 12%, Spurred by Frozen Drinks," *Bloomberg*, July 23, 2010. http://www.bloomberg.com/news/2010-07-23/mcdonald-s-second-quarter-profit-rises-12-spurred-by-frozen-drink-sales.html Accessed August 30, 2010.
46. McDonalds.com. http://www.aboutmcdonalds.com/mcd/our_company/mcd_history.html.

Differentiating Characteristics

In 2002, McDonald's faced falling profits and stock prices along with rising debt. Although they were losing market share, they continued to open new stores. To correct this trend, McDonalds began to concentrate on bringing more customers into existing stores rather than more stores to customers. Low performing stores were closed and the menu was revamped to make it more current (*e.g.*, premium salads and coffee drinks). This new simplified and articulated vision resulted in an eight-fold increase in cash flow in one year, which allowed McDonald's to pay down debt and raise dividends.

Novell

Novell is a multinational software and services corporation headquartered in Waltham, Massachusetts. The company specializes in enterprise operating systems, such as SUSE Linux Enterprise and Novell NetWare; identity, security, and systems management solutions; and collaboration solutions, such as Novell Groupwise and Novell Pulse. Novell was instrumental in making the Utah Valley a focus for technology and software development. Novell technology contributed to the emergence of local area networks, which displaced the dominant mainframe computing model and changed computing worldwide. Today, a primary focus of the company is on developing open source software for enterprise clients.

History

In 1996, the company began a move into Internet-enabled products, replacing reliance on the proprietary IPX protocol in favor of a native TCP/IP stack. The result was NetWare v5.0, released in October 1998, which leveraged and built upon eDirectory and introduced new functions. However, by 1999, Novell had lost its dominant market position, and was continually being out-marketed by Microsoft, which gained access to corporate data centers by bypassing technical staff and selling directly to corporate executives. In October 2000, Novell released a new product that was designed to synchronize data, often user information, between disparate directory and database systems. This product, Novell Identity Manager, leveraged the speed and functionality of eDirectory to store information, and would later form the foundation of a core product set within Novell. In July 2001, Novell acquired the consulting company Cambridge Technology Partners, to expand offerings into

services. Novell felt that the ability to offer solutions (a combination of software and services) was key to satisfying customer demand.

Differentiating Characteristics

Novell underwent extensive downsizing and replaced the executive team (but retained key people), reducing the management layers from seven to four. The company refocused on core engineering strengths, unlocking the creativity and drive of people—a true culture change involving employees in product development—and direct CEO contact with customers. This new product development and launch blitz resulted in a sales increase of 30 percent and profits more than doubled in two years.

Koninklijke Philips Electronics N.V.

Philips, a multinational Dutch electronics corporation, is one of the largest electronics companies in the world. In 2009, its sales were €23.18 billion. The company employs 123,800 people in more than 60 countries.[47] Philips is organized in a number of sectors: Philips Consumer Lifestyles (formerly Philips Consumer Electronics and Philips Domestic Appliances and Personal Care), Philips Lighting, and Philips Healthcare (formerly Philips Medical Systems).

History

The company was founded in 1891 by Gerard Philips, in Eindhoven, Netherlands. Its first products were light bulbs and other electro-technical equipment. In the 1920s, the company started to manufacture other products, such as vacuum tubes (also known worldwide as "valves"). In 1927, they acquired the British electronic valve manufacturer Mullard, and, in 1932, the German tube manufacturer Valvo, both of which became subsidiaries. In 1939, they introduced their electric razor, the *Philishave* (marketed in the U.S. using the Norelco brand name). Philips had early developments of a laser disk for selling movies but delayed its commercial launch for fear of cannibalizing its video recorder sales. Later Philips would join with MCA to launch the first commercial laser disk standard and players. In 1982, Philips would team with Sony to launch compact disc. These formats evolved to the present day DVD and Blu-Ray, which Philips launched with Sony in 1997 and 2006, respectively.

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47. *Annual Report 2007,* Philips. http://www.annualreport2007.philips.com/tools/stream.asp?file=/downloads/files/Philips2007_AnnualReport.pdf.

Differentiating Characteristics

Philips was a 100-year-old company with a fading reputation for innovation and a falling share price, partially due to poor and inconsistent performance. The president was replaced mid-1990 and Philips began to create a two-phase plan to first restructure and then revitalize the company. The first phase involved operational efficiency, to include intense cross-company communications and induce a sense of urgency toward competitor intelligence. The second phase set strategic direction, with the intent to stretch for big objectives. Team building was initiated using active learning for buy-in and commitment. This plan created infrastructure and culture for ongoing change improving all major metrics, restoring pride and confidence in Philips, and the share price doubled.

Qualcomm

Qualcomm Inc. is a wireless telecommunications R&D company, as well as the leading wireless semiconductor supplier in the world, based in San Diego, California. Qualcomm is the inventor of CDMA one (IS-95), CDMA 2000, and CDMA 1xEV-DO, which are wireless cellular standards used for communications. The company also owns a significant number of key patents on the widely adopted 3G technology, W-CDMA. The license streams from the patents on these inventions, and related products are a major component of Qualcomm's business.

History

Qualcomm was founded in 1985 and its first products and services included the OmniTRACS satellite locating and messaging service, used by long-haul trucking companies. In 1990, Qualcomm began the design of the first CDMA-based cellular base station, based upon calculations derived from the CDMA-based OmniTRACS satellite system. Two years later Qualcomm began to manufacture CDMA cell phones, base stations, and chips. In 1999, Qualcomm sold its base station business to Ericsson, and later sold its cell phone manufacturing business to Kyocera. The company is now focused on developing and licensing wireless technologies and selling ASICs that implement them.

In 2000, Qualcomm acquired SnapTrack, the inventor of the assisted-GPS system for cell phones, branded as gpsOne. In 2006, Qualcomm purchased Flarion Technologies. Flarion is creator of the Flash-OFDM wireless base station, and inventor of the "flash" beaconing method and several other innovations in OFDM communications.

Differentiating Characteristics

Qualcomm leverages open source platforms and software environments to accelerate block upgrade functionality enhancements to the market. They aggressively pursue industry partnerships to leverage IT capabilities in developing new market opportunities (*e.g.*, the Open Handset Alliance (www.openhandsetalliance.com)). Qualcomm uses creative crowd sourcing approaches for exploration of new market opportunities, such the release of the augmented reality software development kit and launch of a $200,000 developer competition.[48] As the "leading wireless semiconductor supplier, Qualcomm Inc., handily outperformed the overall market in 2008, with a 15.3 percent increase in revenue. This boosted Qualcomm's market share to 21.7 percent for the year, up from 19 percent in 2007."[49]

Southwest Airlines

Southwest Airlines Co. is an American low-cost airline. The airline has its headquarters on the grounds of Dallas Love Field, Dallas, Texas. Southwest is the largest airline in the world by number of passengers carried per year (as of 2009).[50] Southwest maintains the third-largest passenger fleet of aircraft among all of the world's commercial airlines[51] and is one of the world's most profitable airlines, posting a profit for the 37th consecutive year in January 2010.[52]

History

Southwest Airlines was incorporated in Texas and commenced customer service on June 18, 1971, with three Boeing 737 aircraft serving three Texas cities—Houston, Dallas, and San Antonio. Today, Southwest operates 541 Boeing 737 aircraft between 69 cities. Southwest operates more than 3,300 flights a day

48. *Business Week*, July 1, 2010. http://www.businessweek.com/technology/content/jul2010/tc2010071_433105.htm
49. Cellular-News.com. http://www.cellular-news.com/story/37264.php
50. "Scheduled Passengers Carried," International Air Transport Association. http://www.iata.org/ps/publications/wats-passenger-carried.htm Accessed August 30, 2010.
51. "Southwest Tweaks 'Cattle Call' Boarding Process," Fox News, September 19, 2007. http://www.foxnews.com/story/0,2933,297347,00.html Accessed August 30, 2010.
52. "Southwest Airlines Posts Profit," *The Street*, January 21, 2010. http://www.thestreet.com/story/10664795/southwest-airlines-posts-profit.html Accessed August 30, 2010.

coast-to-coast, making it the largest U.S. carrier based on domestic passengers carried as of September 30, 2009.[53]

Differentiating Characteristics

Southwest minimizes maintenance and training costs by using a single aircraft, the Boeing 737. Another enormous factor differentiating Southwest Airlines is the people. They are very proud of what they have created, and this is one of the reasons the company screens potential employees carefully. Even with the company's tremendous growth, it is not easy to get a job at Southwest today. When a new person is hired, the company sees cause for celebration. New hires spend a full day experiencing the "You, Southwest, and Success" program. By participating in fun, games, and Southwest-style celebrations, new hires learn that success at Southwest means hard work and commitment to the mission of internal and external service.

Southwest has also proven that by limiting aircraft time on the ground, it has been able to maintain an enviable on-time record at a significant cost advantage over its competitors. Travelers are also happy with the process since it saves them time as well. Southwest is not resting on their laurels though. This year, Southwest conducted a limited test of several boarding methods to see how much time is required to "turn" the aircraft if customers are holding an assigned seat for 200 separate departures at the San Diego airport. Southwest ultimately wants to measure the combined success of assigned seating, customer satisfaction, on-time performance, and efficiency on its business model.[54]

Tata Steel

Tata Steel, formerly known as TISCO and Tata Iron and Steel Company Limited, is the world's seventh largest steel company,[55] with an annual crude steel capacity of 31 million tons. It is the largest private sector steel company in India in terms of domestic production. Ranked 258th on *Fortune* Global 500, it is based in Jamshedpur, Jharkhand, India.[56,57] It is part of the Tata Group of companies. Tata Steel is also India's second-largest and second-most profitable company in the private sector.[58]

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53. Southwest.com. http://www.southwest.com/about_swa/press/factsheet.html - Distinctions
54. "Creativity And Innovation Driving Business - Innovation Index," December 16, 2006. http://creativityandinnovation.blogspot.com/2006/12/southwest-airlines-flying-high-with.html
55. Worldsteel Association. http://www.worldsteel.org/?action=programs&id=53
56. Tatasteel.com. http://www.tatasteel.com/corporate/company-profile.asp

History

Tata Steel was established by Indian Parsi businessman Jamsetji Nusserwanji Tata in 1907. Tata Steel introduced an 8-hour workday as early as in 1912, when only a 12-hour work day was the legal requirement in Britain. It introduced leave-with-pay in 1920, a practice that became legally binding upon employers in India only in 1945. Similarly, Tata Steel started a Provident Fund for its employees as early as 1920, which became a law for all employers under the *Provident Fund Act* only in 1952. Tata Steel's furnaces have never been disrupted on account of a labor strike—an enviable record.

Differentiating Characteristics

Tata spent decades operating as a protected Indian industry bred in complacency with outdated technology and poor customer responsiveness. Industrial liberalization forced change. Tata began a three-phase program in 1992, which worked towards a top-down emphasis on quality after decades of poor quality and productivity. Tata began to identify and leverage several strengths, including harnessing un-utilized captive raw materials, benchmarking global best, increasing furnace utilization, and reducing labor. Customer focus was restructured as two profit center business units with integrated manufacturing and sales. These changes enabled Tata to successfully change core operations, processes, and culture, resulting in sales that grew five-fold from 1993 to 2004.

Warnaco Group Incorporated

Warnaco is an American textile/apparel corporation that designs, sources, markets, licenses, and distributes a wide range of intimate apparel, sportswear, and swimwear worldwide. Its products are sold under several brand names, including Calvin Klein, Speedo, Chaps, Warner's, and Olga.

57. "Tata Steel plans pooling of raw materials," *The Economic Times*, June 28, 2008. http://economictimes.indiatimes.com/News/News_By_Industry/Indl_Goods__Svs/Steel/Tata_Steel_plans_pooling_of_raw_materials/articleshow/3169810.cms
58. "Corus buy hauls Tata Steel next to Reliance," Battakiran's Weblog, http://battakiran.wordpress.com/2008/06/27/corus-buy-hauls-tata-steel-next-to-reliance-in-revenues/

History

In 1986, after being away from the company for nine years[59], former lingerie division president Linda J. Wachner engineered a $550 million hostile takeover.[60] The company's success peaked in 1998 with $1.95 billion in revenue.[61] Soon after, however, sales dropped rapidly and—saddled with debt from all the recent acquisitions and mergers—in 2000, the company lost $200 million.[62] In 2001, Warnaco filed for Chapter 11 protection and Wachner was fired. On February 4, 2003, Warnaco emerged from bankruptcy.

Differentiating Characteristics

As part of its restructuring, the company repositioned, sold, or liquidated eight non-core divisions and focused on three products. Warnaco began practicing aggressive inventory control, closing or downsizing stores, replaced 40 percent of its finance staff, and was able to return to profitability in one year. Since emerging from bankruptcy, Warnaco Group's annual income reports have shown steady growth.[63] As of January 2, 2010, the company operated over 1,000 Calvin Klein retail stores worldwide as well as three online stores.[64] It also licenses or franchises an additional 624 stores, and the Calvin Klein brand accounted for 75 percent of the Warnaco Group's $2 billion net sales in 2009.[65] At the end of 2010's second quarter (ending July 3), Warnaco reported that all three divisions—intimates, swimwear, and sportswear—contributed to its 14 percent growth in net revenues to $519.3 million, and industry analysts expect continued growth.[66]

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59. Linda Joy Wachner. *American Women Managers and Administrators: A Selective Biographical Dictionary of Twentieth-Century Leaders in Business, Education, and Government,* Westport, Ct.: Greenwood Press, 1985, pp. 279, ISBN 0313237484.
60. Linda Wachner. *Overview, Personal Life, Career Details, Social and Economic Impact, Chronology,* Online Encyclopedia. http://encyclopedia.jrank.org/articles/pages/6381/Wachner-Linda.html Accessed August 20, 2010.
61. The Gale Group. "The Warnaco Group Inc. -- Company History," *Funding Universe*.
62. Steve Forbes and John Prevas. "The Price Of Arrogance: The ugly stepsister of success is often a loss of discipline," Forbes.com, June 18, 2009. http://www.forbes.com/2009/06/18/alexander-great-hubris-leadership-power.html Accessed August 21, 2010.
63. "Income Statement," IR Fundamentals, Warnaco Group, Inc.
64. "WARNACO GROUP INC /DE/ CIK#: 0000801351," United States Securities and Exchange Commission. http://www.faqs.org/sec-filings/100302/WARNACO-GROUP-INC-DE-_10-K/ Accessed August 24, 2010.
65. Gene Marcial. "Inside Wall Street: Calvin Klein Is Making Warnaco Look Sharp," April 9, 2010, DailyFinance, AOL Money & Finance. http://www.dailyfinance.com/story/investing/inside-wall-street-calvin-klein-is-making-warnaco-look-sharp/19431861/ Accessed August 24, 2010.
66. "Swimwear up as Warnaco reports Quarter 2 surge." Surfersvillage Global Surf News. August 10, 2010. http://www.surfersvillage.com/surfing/48089/news.htm Accessed August 24, 2010.

Defense Examples

Acoustic Rapid COTS Insertion

In the mid-1990s, the submarine Navy faced a reduced superiority in anti-submarine warfare when the rest of the world's submarine quieting began to catch up with the U.S. Navy's capabilities. The challenge for the U.S. Navy was that technological superiority must be maintained despite higher costs for development, reduced funding, and any modernization efforts to be compatible with the new *Virginia* (SSN-774)-class submarine.[67] The Acoustic Rapid COTS Insertion (ARCI) program provides an efficient and effective answer to this issue by rapidly procuring commercial off-the-shelf (COTS) hardware and software.

History

The ARCI program began in 1996 with the objective of applying state-of-the-art signal processing with state-of-the-practice COTS hardware and software. The program provides a cost-efficient way to restore the acoustic superiority of the submarine Navy and provide ways to sustain their superiority. The guiding principles for the ARCI program include: (1) rapid COTS insertion; (2) deliver the full theoretical gain to the operation of each sensor; (3) avoid modifying successful commercial products; (4) use lessons learned; (5) use state-of-the-practice, not state-of-the-art systems; (6) configuration management, not configuration control; (7) software reuse is key to affordability; (8) no single organization has the full story; and (9) sub-acoustic superiority depends on the successful use of these axioms. In parallel with ARCI, the Navy has created common requirements specifications to ensure commonality across the submarine fleet in software, hardware, supply support, training, and test efforts. Lockheed Martin is the lead contractor for the ARCI program, and partners with Digital System Resources, the University of Texas Applied Research Laboratory, and Johns Hopkins University. The program includes a bottom-up, data-driven, and peer-reviewed competitive process to ensure that new concepts are

67. Lockheedmartin.com.
http://www.lockheedmartin.com/products/AcousticRapidCOTSInsertion/model-for-future.html

assessed, simulated, and tested at sea to determine their success before being integrated in the following year's fleet-capable systems delivery.[68]

Differentiating Characteristics

The ARCI program has led the way at the Naval Sea Systems Command in open architecture implementation and launched a new way of doing business by having a capabilities-based process versus a requirements-based process.[69] The program has delivered an integrated development plan that accommodates asymmetric upgrades for all classes of submarines and their combat systems. Implementation includes six Technology Insertion Upgrades with an additional nine Advanced Processing Build Capability Updates that will be applicable to the entire Submarine Combat System market. The updated acquisition program baseline and technology insertion business model provide better integration with training. Finally, this program implemented guidance from the Program Executive Office Integrated Warfare Systems office on open architecture into ongoing procurement actions.

Advanced Medium-Range Air-to-Air Missile

The Advanced Medium-Range Air-to-Air Missile (AMRAAM) is a beyond-visual range air-to-air missile that can be carried on a variety of fighter aircraft. It was designed as a follow-on to the AIM-7 Sparrow missile series, as a smaller, lighter, faster, and improved missile that is more accurate against low-altitude targets.[70]

History

AMRAAM is the result of a 1975 study that recommended future missiles engage aerial threats at a 3-40 mile range. Five contractors competed in a conceptual program sponsored by the U.S. Air Force in 1979, with two contractors, Hughes Aircraft Company and Raytheon, continuing on to the validation phase. The validation phase included building actual hardware to demonstrate the technological concepts.

68. Lockheedmartin.com. http://www.lockheedmartin.com/products/AcousticRapidCOTSInsertion/model-for-future.html
69. Lockheedmartin.com. http://www.lockheedmartin.com/products/AcousticRapidCOTSInsertion/model-for-future.html
70. Wikipedia.org. http://en.wikipedia.org/wiki/AIM-120_AMRAAM

At the end of the 33-month validation phase, the U.S. Air Force awarded the development contract to Hughes Aircraft Company in 1981. In 1987, a production contract was awarded to both Hughes Aircraft and Raytheon as a joint Air Force and Navy program.[71] The missile entered operational service in 1991 with the U.S. Air Force and in 1993 with the U.S. Navy. The AMRAAM was first used in December 1992 on an Iraqi MiG-25 that entered the southern no-fly zone, with a second victory in January 1993, again on an Iraqi MiG-25. Since then, multiple variants of the missile have been developed with improved capabilities. The most recent variant is the AIM-120D, with a 50 percent greater range than previous variants. The AIM-120D entered the testing phase in mid-2008 and is currently in the full-production phase.[72]

Differentiating Characteristics

The AMRAAM program is expected to remain in U.S. Air Force and U.S. Navy service until at least 2020. The program has been successful partly due to the extensive user involvement in the development and upgrade processes. Twice a year, the Air Force and Navy meet to determine what future investments should be pursued. This meeting invites operators as participants to include their experiences as guidance to future investments. Also, a "mini IPT" (integrated product team) with both Air Force and Navy war fighters has worked successfully to understand needed capability improvements to the AMRAAM missile system. The program also uses extensive modeling and simulation, including hardware-in-the-loop simulations, to support performance trades and concepts of operation (CONOP) development. Finally, the AMRAAM System Program Office is provided data from AMRAAM so it can evaluate the data and recommend future improvements.

Army Digitization Program

The Army Digitization Program focuses on providing systems that achieve a tactical internetworked C3I (command, control, communications, and intelligence) system to significantly enhance situation awareness, force integration, combat identification and target hand-off, and database distribution and communications.[73] This would coincide with Force XXI realignment of personnel to develop smaller, more streamlined brigades and divisions. The digital command and control platforms

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71. Federation of American Scientists, Military Analysis Network. http://www.fas.org/man/dod-101/sys/missile/aim-120.htm
72. Wikipedia.org. http://en.wikipedia.org/wiki/AIM-120_AMRAAM
73. Federation of American Scientists, Military Analysis Network. http://www.fas.org/man/dod-101/army/docs/astmp/c7/P7F5.htm

that enable a digitized army is the Force XXI Battle Command Brigade and Below (FBCB2) platform that allows one to see your own location, as well as locations of both enemies and allies on the battlefield in real-time.[74]

History

The Army Digitization Program sprang from the concept of horizontal technology integration, to provide near real-time visual display to every unit and weapon system allowing a common situational awareness by all soldiers and leaders engaged in combat.[75] The FBCB2 system developed to support this initiative provides: real-time situational awareness for commander, staff, and soldiers; a shared common picture of the battle space; graphical displays, with friendly and enemy unit locations; target identification; integrated logistics support; and communications and electronics interfaces with host platforms. The existing platforms that FBCB2 interfaces with are the Army Tactical Command and Control Systems and the embedded C4I (command, control, communications, computers, and intelligence) capable systems, such as the M1A2 Abrams, the M2A3 Bradley, the AH-64D Longbow Apache, and the OH-58D Kiowa Warrior.[76]

Personnel integration is also an important element of the Army Digitization Program. The first digitized division was the 4th Infantry Division (Mechanized) stationed at Fort Hood, Texas.[77] The 4th Infantry Division (Mechanized) participated in Army Warfighting Experiments in both 1997 and 2001 to demonstrate what combat forces linked together by the FBCB2 with real-time information could bring to the battlefield. The 2001 experiment proved that the 4th Infantry Division was trained and ready as the first digitized division in the U.S. Army, with a smaller (on paper) division structure and 24 percent fewer combat platforms, mostly in the armor and infantry battalions. Despite the smaller personnel and vehicle size, the 4th Infantry Division had increased combat lethality, survivability, and speed due to the implementation of the Army Digitization Program and FBCB2.

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74. Globalsecurity.org, Military.
http://www.globalsecurity.org/military/agency/army/4id.htm
75. Globalsecurity.org, Military.
http://www.globalsecurity.org/military/agency/army/force-xxi.htm
76. Federation of American Scientists, Military Analysis Network.
http://www.fas.org/man/dod-101/sys/land/fbcb2.htm
77. Globalsecurity.org, Military.
http://www.globalsecurity.org/military/agency/army/4id.htm

Differentiating Characteristics

The Army Digitization Program was successful because of the continuity of top down leadership that provided a broad vision for the program. Also, funds were moved to support the program, as well as personnel reassigned to implement it. The test and training communities were both active participants in the program. The test community participated in the system development and test techniques, while the training community was involved by utilizing the National Training Center to experiment and assess the effectiveness of a digitized military. Throughout the entire program life, contractors played a active part in system development and battlefield testing.

Army Shadow Program

The RQ-7 Shadow Tactical Unmanned Aerial Vehicle (TUAV) was first selected for production in 1999 to fill the void for a TUAV after the RQ-6 Outrider was cancelled. The Shadow TUAV has a range of over 60 miles and has landing gear similar to Navy fighter jets, with a tailhook that catches an arresting wire, allowing the TUAV to stop in less than 170 feet.

History

The Shadow TUAV was produced after 20-plus years of failed unmanned aerial vehicle (UAV) programs that had resulted in a loss of leadership trust in a successful outcome. Multiple adversaries were already flying UAVs in the late 1990s, while the U.S. military faced one failure after another for a successful UAV. The Joint U.S. Army and U.S. Marine Corps program, the RQ-6 Outrider, could not meet the requirements for a tactical UAV. The requirements specified that the UAV must use a gasoline engine, be able to carry an electro-optic/infrared imaging sensor turret, have a minimum range of 31 miles, and be able to fly for four hours and then land on an athletic field.[78] The Shadow meets all of the above requirements. The landing gear utilizes the Navy practice of an arresting wire connected to brakes that catches a tailhook on the aircraft to stop the vehicle quickly. The new acquisition strategy put in place for the Shadow program focused on having a reliable platform with

78. Wikipedia.org. http://en.wikipedia.org/wiki/AAI_RQ-7_Shadow

minimum SWAP (size, weight, and power) for payload, and allowed for block improvements, so that the aircraft could be put in service while improvements were being made. The RQ-7A Shadow was delivered in September 2003, with the second variant delivered less than a year later in the summer of 2004.

Differentiating Characteristics

The acquisition process for the Shadow began with a commercial systems capability demonstration in October/November 1999. This demonstration allowed the commercial sector to help set a baseline for the system's technical and operational performance requirements, as well as provide input to the TUAV source selection.[79] A competitive fly-off was conducted after a down select to further assess risk. This process allowed for the selection of the AAI Corporation's TUAV, the Shadow, to replace the cancelled RQ-6 Outrider. The Shadow followed a rapid production and fielding schedule and was deployed to combat in less than five years. Because the acquisition process allowed for block improvements, Shadow II and the Raven followed quickly due to concurrent improvements to the Shadow system while it was in active service.

Big Safari

Big Safari is an acquisition program office in the U.S. Air Force that manages the sustainment and modification of specialized mission aircraft. The program is a specialized process of acquisition and contracting management processes that are used to accomplish special projects on a quick-reaction basis. At any one time the office supports 20-24 projects and the logistics sustainment of over 50 aircraft.

History

Big Safari was created in 1952 as a response to Soviet ICBM (intercontinental ballistic missile) and nuclear weapons development. The program is often referred to as "the special operations force of the acquisition community" and provides quick reaction capability to the U.S. Air Force and U.S. Special Operations Command (USSOCOM), as well as non-military U.S. government agencies. Program management resides in Detachment 4, 645th Materiel Squadron, U.S. Air Force Aeronautical Systems Center, Wright-Patterson Air Force Base in Dayton, Ohio. The program is only focused on current and near-term war fighting needs and is meant to provide rapid

79. Globalsecurity.org, Military. http://www.globalsecurity.org/intell/systems/shadow.htm

acquisition for improved systems. The process is more streamlined than any other acquisition program because of its authority and currently operates with minimum funding due to the effectiveness of its management procedures. However, the program realized increased cost savings after the implementation of the acquisition reform initiatives.[80]

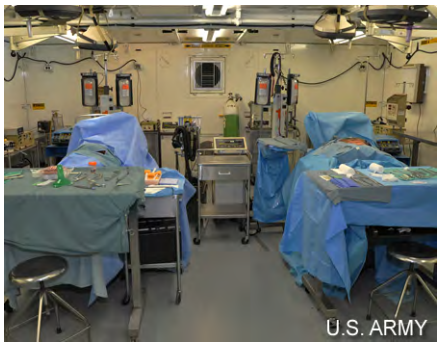
Differentiating Characteristics

The Big Safari program has had 60 years of success. Employees of the program stay a long time and remain dedicated to its mission throughout their service. Contractors that work within the program understand the quick reaction capability business and the "80 percent solution now" need. Most of these employees have operational military background. The program aggressively seeks feedback from the operator and end-user of each system to ensure its success.

Combat Support Hospital

Combat Support Hospitals (CSHs) are mobile, deployable hospitals that are housed in tents and expandable containers. They provide surgical and trauma care close to combat actions as either one 248-bed hospital or as two geographically separate hospitals.

History



Recently, the Army Surgeon General asked for a review of its CSHs to determine the actual needs and future way ahead for improvements. Currently, CSHs operate as hospitals only when they are deployed and are used for training when at home. Much of the current stock of CSH equipment is stored at the Sierra Army Depot because deployments occur once every 3-5 years for CSHs. During the time that the equipment is stored, much of it becomes obsolete without ever receiving any use.[81] The issue is how to ensure that the CSHs remain

80. Globalsecurity.org, Military. http://www.globalsecurity.org/intell/systems/big_safari.htm
81. RAND Corporation, "New Equipping Strategies for Combat Support Hospitals." http://www.rand.org/pubs/monographs/MG887/

state of the art, without spending unnecessary dollars on medical equipment that may never be used in deployments.

A 2010 study, conducted in response to the Army Surgeon General's request, analyzed the equipment inventory and its current uses. The study also surveyed CSH personnel from both active and reserve components to get war fighter inputs, through focus groups and individual interviews. A new equipping and maintenance strategy was developed based on the inventory analysis and war fighter inputs to fit the future need of CSHs.

Differentiating Characteristics

The new strategy results in fewer, regularly modernized full hospital sets system-wide, while improving training and deployed capabilities. This results in less total medical equipment, which will reduce maintenance and upgrade costs and also ensure that CSH equipment is well maintained and state of the art. The total equipment replacement cost at 2010 prices would decrease by about 25 percent, from $1 billion to $740 million.

F-117

The F-117 is the first plane to be developed based on stealth technology. Soviet/Russian mathematician Pyotr Ya Ufimtsev first developed the theoretical basis for the F-117, in the 1960s. He determined that the configuration of an object, not its size, is what determines the strength of its radar return.[82] This project ran from 1975 until 2008 when all F-117s were retired. A streamlined management process allowed for the aircraft to be rapidly fielded within 31 months of the full-scale development decision.[83]

82. Wikipedia.org. http://en.wikipedia.org/wiki/Lockheed_F-117_Nighthawk
83. Federation of American Scientists, Military Analysis Network. http://www.fas.org/programs/ssp/man/uswpns/air/attack/f117a.html

History

The F-117A began as a "black" program in 1975 with the development of the "Hopeless Diamond," a model to demonstrate the feasibility of applying Pyotr Ya Ufimtsev's theory to a fighter jet. The decision to produce the F-117 was made in 1978, and the production contract was awarded to Lockheed Advanced Development Projects, otherwise known as "the Skunk Works." The F-117A's first flight was in June 1981, only 31 months after the decision was made to produce the new jet. Initial operation capability status was achieved in October 1983, while the program was still completely "black." The first fleet of jets was based at the Tonopah Test Range Airport in Nevada. The F-117 was publicly acknowledged and revealed to the world in November 1988 after a photograph was released to the public. The F-117A was widely used and publicized during the Persian Gulf War of 1991 and has been used in most military operations since, including Operation Enduring Freedom and Operation Iraqi Freedom. There has only been one lost in combat, during the Kosovo War in 1999.[84] The Air Force retired the F-117 in 2008, with the final two retired on April 22, 2008 to the Tonopah Test Range Airport, Nevada in a "recallable state of storage."[85]

Differentiating Characteristics

The Air Force stated that streamlined management by the Aeronautical Systems Center at Wright-Patterson Air Force Base in Ohio allowed breakthrough stealth technology to be concurrent with the development and production of the F-117 for rapid fielding of the aircraft.[86] The program had total leadership support and an exceptional and fully qualified staff, as well as a true cross-functional integrated team that was empowered to make decisions on the spot. Also, periodic program team meetings focused on making the program successful rather than just saying "no" to any changes, by reviewing program performance from all perspectives. This process allowed key performance parameters to be met and trade-offs of sub-tier performance parameters be made so that cost and schedule requirements were achieved. A 1996 RAND report recommended that the acquisition process for the F-117 should be applied to other programs.[87]

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84. Wikipedia.org. http://en.wikipedia.org/wiki/Lockheed_F-117_Nighthawk
85. Federation of American Scientists, Military Analysis Network. http://www.fas.org/programs/ssp/man/uswpns/air/attack/f117a.html
86. Ibid.
87. Giles K. Smith, Hyman L. Shulman, Robert S. Leonard. *Application of F-117 Acquisition Strategy to Other Programs in the New Acquisition Environment*, Santa Monica, California, RAND Corporation, 1996. http://www.rand.org/pubs/monograph_reports/MR749/

F-15

The F-15 is an all-weather tactical fighter designed to gain and maintain air superiority in aerial combat. The plane was developed in 1967, first flown in 1972, and entered U.S. Air Force service in 1976. It is considered the most successful of the modern fighters with no losses in dogfights and over 100 aerial combat victories.

History

The F-15 Eagle is a twin-engine tactical fighter developed by McDonnell Douglas, now Boeing, in 1967 in response to the Air Force's 1965 request for proposals for a new fighter jet. The F-15 Eagle proved to be superior to the other eight competitors and McDonnell Douglas was awarded the contract in 1969. By the time the contract was awarded, the Air Force was particularly concerned with procuring a fighter jet that could maintain air superiority over the new Soviet MiG-25 Foxbat being developed at the same time. The F-15 Eagle entered service in 1976 with two variants, the F-15A, a single-seat aircraft and the F-15B, a twin-seat training aircraft. The F-15 is equipped with "look-down/shoot-down" radar that can distinguish low-flying moving targets from ground clutter, decreases pilot workload with new computer technology, and requires only one pilot for the aircraft. The F-15 has multiple variants including the initial variants of the F-15 A/B discussed above. The F-15C is an improved single-seat fighter version, while the F-15D is a two-seat version developed for training. The F-15J and F-15DJ were both developed for Japan as a single-seat fighter aircraft and twin-seat training version, respectively.[88] A variant was developed in the early 1970s for the U.S. Navy, designated as the F-15N Sea Eagle. The F-15E Strike Eagle variant improves the ground attack capability of the F-15C variant.[89]

Differentiating Characteristics

The F-15 is expected to be in operational service until 2025 and used by both the U.S. Air Force and U.S. Navy. Constant block improvements allow the aircraft's

88. Wikipedia.org http://en.wikipedia.org/wiki/McDonnell_Douglas_F-15_Eagle
89. Federation of American Scientists, Military Analysis Network. http://www.fas.org/programs/ssp/man/uswpns/air/fighter/f15.html

armament to be continuously updated to meet the evolving threats of future warfare. In 2009, the Air Force retrofitted 178 F-15C aircraft with Active Electronically Scanned Array radar.[90] Future plans include retrofitting other F-15C aircraft with the Joint Helmet Mounted Cueing System, an updated system for situational awareness and weapons targeting.[91]

F-16

The F-16 Aircraft is a highly maneuverable, multi-role fighter jet, though it is mostly used as a dogfighter. It is compact and provides the Air Force and Navy with a relatively low-cost, high-performance weapon system.[92] The F-16 became operational in 1979 with the formal nickname of "Fighting Falcon." Over time many pilots have informally nicknamed the F-16 the "Viper" because of its resemblance to a viper snake.

History

The Vietnam War revealed the need for the United States to develop better air-to-air fighter jets in order to maintain the country's air superiority. In response, DOD determined that a small, lightweight aircraft would be necessary to fulfill the gaps revealed in Vietnam. The first YF-16 was rolled off the production line in 1973 by General Dynamics and had its first flight in 1974; however, the aircraft did not enter operational service until 1979. In 1974, DOD was aiming to achieve greater commonality of aircraft between the Air Force and Navy in order to reduce costs, and thus made a decision to sponsor a competition for a new fighter jet that could be used by both. Four U.S. allies had also reached an agreement with the United States that they would acquire for their own militaries whichever fighter jet the United States decided to procure. After participating in a competition with three other competitors, General Dynamic's YF-16 proved to be the superior plane with the lowest operating costs, and greater maneuverability and range. The YF-16 also performed at near-supersonic and supersonic speeds.

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90. Wikipedia.org http://en.wikipedia.org/wiki/McDonnell_Douglas_F-15_Eagle
91. Wikipedia.org http://en.wikipedia.org/wiki/Joint_Helmet_Mounted_Cueing_System#Joint_Helmet_Mounted_Cueing_System_.28JHMCS.29
92. U.S. Air Force. http://www.af.mil/information/factsheets/factsheet.asp?id=103

Acquisition Program—Key Elements of Success and Lessons Learned

The F-16 development is considered one of the most successful major programs in history, and is a model that could be adopted to implement the acquisition improvements outlined earlier in this report (Part A. Chapter 3. Align Enterprise Functions to Support Mission Outcomes).

The F-16 has gone through 27 block upgrades since 1979 (Table A-1).[93] The block approach permitted grouping of planned operational improvements based on technology readiness, funding availability, user prioritization, and program execution assessments. These variants include the F-16 A/B, F-16 C/D, F-16 E/F, F-16 VISTA, and F-16XL. Block 15 of the F-16 A/B increased the size of the horizontal stabilizers and was the most popular variant with the largest number, 983 aircraft, produced. The F-16 C/D variant added an all-weather capability and the glass cockpit for better visibility and targeting ability. The F-16 E/F is the most recent variant of the aircraft, but is not part of the U.S. Air Force inventory; instead they have been produced for export only. Neither the F-16 VISTA nor the F-16XL has been pursued by the Air Force or Navy for procurement.

Senior Air Force leaders, concerned about cost growth in the F-14 and F-15 programs, set in motion a high/low mix strategy that formed the basis of the block development of the F-16 program. This program was known as the Multinational Staged Improvement Program [MSIP].[94]

The F-16 MSIP was also planned to align the entire "enterprise" of subsystems, weapons, and avionics developments being planned in the Air Force at the time. Their intended use on the F-16 and F-15 became the basis for justifying all of these subsystems. However, their schedules and budgets for were not at all coordinated with the development schedule for the F-16.

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93. For detailed descriptions of the F-16 blocks, see: http://www.f-16.net/f-16_versions.html
94. Description of the key elements of the program's success is based on interviews, November 2010, with General USAF ret. Ron Yates, former F-16 SPO director 1983-1986, Later Commander AF Systems Command; General USAF ret. Mike Loh, former Prototype Lightweight Fighter Program Office and SPO office 1973-1977, later Commander Air Combat Command; and General USAF ret. Les Lyles, Commander AF Systems Command.

Table A-1. F-16 Block Development and Manufacturing Approach

F-16 Versions, Production Blocks, and Experimental Versions	
F-16 LWF	Light Weight Fighter
YF-16	The Birth of a Fighter
F-16A/B	Block 1/5/10/15/15OCU/20
F-16C/D	Block 25 (new radar, new cockpit, new avionics)
F-16C/D	Block 30/32 (improvements to Block 25, and new GE engine in Block 32)
F-16C/D	Block 40/42 (LANTIRN and improved air-to-ground capabilities)
F-16C/D	Block 50/52 (improved radar and air-to-air capabilities)
F-16E/F	Block 60 (export version)
F-16 MLU	Mid-Life Update
F-16 ADF	Air Defense Fighter
(T)F-16N	F-16 for the US Navy
RF-16/F-16(R)	Recce Versions
A-16, F/A-16, F-16A (30mm gun)	F-16s for the CAS/BAI missions
F-16/101	Derivative Fighter Engine
F-16/79	FX Export Fighter
F-16/CCV	Control Configured Vehicle
F-16 XL	Cranked-Arrow Wing
F-16 AFTI	Advanced Fighter Technology Integration
F-16 VISTA/MATV/ NF-16D	Variable-stability In-flight Simulator Test Aircraft, Multi Axis Thrust Vectoring
F-16 GCAS	Ground Collision Avoidance System
F-16 LOAN	Low Observable Asymmetric Nozzle
F-16 ES	Enhanced Strategic
F-16 SFW	Swept Forward Wing
F-16X	The Tailless Fighter
F-16 FSX/F-2	F-16 Inspired Japanese Fighter
F-16 - Various	Agile Falcon/production extension
US Tri-Service Aircraft Designations	DOD Mission, Design, and Series System (MDS)

The F-16 program directors aligned the schedules and budgets of programs like AMRAAM, Laser Guided bombs, AIM-7F, Seek Talk radio, the Westinghouse APG-68 radar, incorporation of Mil-Std 1750 computer instructions/Mil-Std 1760 stores interface/Mil-Std 1553 data bus, and others to ensure a coordinated plan to incorporate these capabilities on the F-16 when their individual developments were completed. Likewise, since this was a "multinational" program with the F-16s 'European Partners Group' (Belgium, Netherlands, Norway, and Denmark), some capabilities from these nations were also factored into the MSIP plans.

The F-16 Systems Program Office (SPO) developed the block roadmap and coordinated it with Tactical Air Command. The roadmap was developed with a long-term view. Blocks 30-50 were conceived at the same time and out year funding was instituted to support them. The operators were thus confident of when they would receive operational improvements so they could properly plan military construction, training, operational tests, and tactics development. The SPO was committed to the development schedule, managed the development program to correspond to a time and budget baseline, and had time to adequately plan the incorporation of improvements in production.

Program funding at the requested amount included a management reserve of approximately 6 percent. The Air Force and DOD did not raid the management reserve during budget drills. The reserve was included with each project in the program (there were over 425), so headquarters could eliminate a capability and it's reserve, but it could not just cut the management reserve and retain the capability requirement.

The F-16 SPO was properly manned and experienced, with 610 people including some knowledgeable fighter pilots. This was essential to the "healthy tension" between operators and acquirers. The operator could not just "throw a requirement over the fence" and expect the SPO to accept it without question. Further, no new requirements were accepted without adding funding to the program to accommodate them.

In addition, the Air Force Chief of Staff showed strong support in the program and was briefed quarterly by the SPO director. The SPO director was thus able to request top cover when outside influences threatened to impact the program. Mainly, however, the regular meetings preempted outside meddling because everyone knew that the SPO director had better access to top Air Force leadership than almost anyone.

Finally, management and review authority were straight lined from the Secretary of the Air Force and Chief of Staff, through the Commander of Air Force System Command, to the SPO director. There was no program executive office (PEO) system. Authority and responsibility were clear.

Differentiating Characteristics

The F-16 aircraft program is unique in that the aircraft has successfully evolved from a light-weight daytime fighter jet into a multi-role aircraft used by the U.S. Air Force active, reserve, and Air National Guard units as well as by the U.S. Navy.[95] The wide use of the aircraft increases the commonality of aircraft across DOD, which decreases budgets for maintenance and service of individual aircraft. The aircraft is planned to remain in service until 2025, which is possible due to the continuous block improvements, allowing the aircraft to be updated to meet evolving threats.

F-18 E/F

The F-18 E/F Super Hornet was developed to be a multi-role fighter jet that can easily switch between various missions with a flip of a switch. These missions include: day/night strikes with precision-guided weapons, anti-air warfare, fighter escort, close air support, suppression of enemy air defense, maritime strike, reconnaissance, forward air control, and tanker.[96] This versatility provides the Navy with an interoperable and common element for air missions.

History

The F-18 E/F is essentially a new model over the previous F-18 C/D Hornet. Though there are common features between the two aircraft, the F-18 E/F is significantly larger and more advanced than the previous models. The F-18 E/F was first ordered in 1992 to replace the previous Hornet and the F-14 Tomcat. The aircraft had its first flight in 1995 with testing commencing in 1996. Full production was begun in September 1997 with testing continuing through 1999. Initial operational capability was achieved in mid-2001, with the Super Hornet meeting

95. Wikipedia.org. http://en.wikipedia.org/wiki/General_Dynamics_F-16_Fighting_Falcon
96. Boeing.com. http://www.boeing.com/defense-space/military/fa18ef/index.htm

cost, schedule, and weight requirements. The multi-role use of the Super Hornet will reduce the number of individual aircraft maintained by the Navy, saving $1 billion in annual fleet wide expenses by replacing aircraft with the Super Hornet.[97]

Differentiating Characteristics

The F-18 E/F Super Hornet project was a successful naval program since it met the cost, schedule, and weight requirements. The Super Hornet was largely a new aircraft and was active within five years of the decision to pursue production. The aircraft has a dramatic decrease in radar cross-section from previous models and other active naval aircraft. Also, the use of continuous block improvements made this program unique in that similar but improved aircraft are continuously being produced to meet changing needs and requirements. The aircraft is planned to be in service through 2024 due to the continuous block improvements meeting future warfare requirements.

F-22 Raptor

The F-22 Raptor is a fifth generation, single-seat, twin-engine fighter aircraft that uses stealth technology. It was designed as an air superiority fighter, but also has ground attack, electronic warfare, and signals intelligence capabilities.

History

In 1981, the U.S. Air Force developed a new requirement for an Advanced Tactical Fighter to replace the F-15 Eagle A/B/C and D variants. A request for proposals was issued in 1986 for a prototype aircraft in which two teams, Lockheed/Boeing/General Dynamics and Northrop Grumman/ McDonnel Douglas competed. As the development phase continued, the increasing costs and takeoff weight of the aircraft meant than many features were sidelined in order to meet the programs weight, cost, and schedule requirements. In April 1991, the Air Force awarded the Lockheed team the contract for production of the F-22. The maiden flight of the F-22 was in September 1997, and the aircraft entered service in

97. Wikipedia.org. http://en.wikipedia.org/wiki/Boeing_F/A-18E/F_Super_Hornet

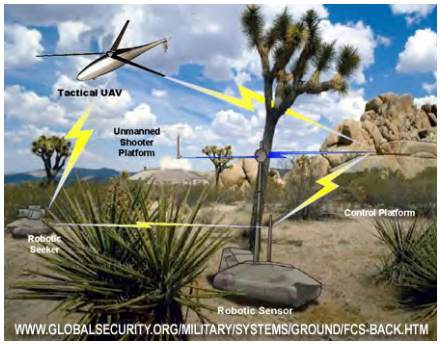
late 2005. In 2006, the F-22's development team won the Collier Trophy, the most prestigious award for American aviation. As of 2010, 168 F-22s had been built and placed in service. A total of 187 are planned to be in service by 2011.

Differentiating Characteristics

The F-22 Raptor program was a success in terms of avionics, but as of 2006, the Comptroller General of the United States stated that "the DOD has not demonstrated the need or value for making further investments in the F-22A program." Despite this statement, funding for the F-22 remained in the defense budgets through 2008, with an actual increase in the number of expected F-22s. However, the Obama administration and Secretary of Defense Gates have announced that production of the F-22 will be phased out by 2011, leaving the total number of F-22 fighters at 187. This phase-out is in response to the increase capabilities of the new F-35, which is a multi-service, multi-role, and more advanced aircraft. The October 2009 defense budget signed by President Obama terminates the F-22 jet fighter program.[98]

Future Combat System

The Future Combat Systems (FCS) program was the principal Army modernization strategy from 2003 to 2009. FCS was envisioned to create new brigades with new manned and unmanned vehicles linked together by a fast and flexible battlefield network.[99] The project was led by the Boeing Company and SAIC as the system integrators.



History

The FCS included unattended ground sensors, unmanned aerial vehicles, unmanned ground vehicles, and eight manned ground vehicles all linked together by a network. The Stryker Brigade Combat Teams were planned to be the interim capability until the full FCS capability could be fielded in 2032 with new manned ground vehicles.[100] The program began in 2003 and by 2005 it met 100 percent of

98. Wikipedia.org. http://en.wikipedia.org/wiki/Lockheed_Martin_F-22_Raptor
99. Wikipedia.org. http://en.wikipedia.org/wiki/Future_Combat_Systems
100. Globalsecurity.org, Military.
http://www.globalsecurity.org/military/systems/ground/fcs.htm

the criteria of the Systems of Systems Functional Review, its most important milestone. However, in October 2005, the Pentagon recommended delaying the FCS program because of the costs of the Iraq War, Hurricane Katrina, and expected declines in future DOD budgets. In January 2006, DOD announced that $256 million was being cut over five years from the $25 billion FCS 2007-2011 budget. By December 2006, funding had been scaled back further on critical elements of the FCS battle space and the most advanced elements had been deferred. A June 2009 memo cancelled the Future Combat Systems program and replaced it with separate programs under the Army Brigade Combat Team Modernization umbrella that the Army has planned.[101]

Differentiating Characteristics

The FCS program, initially very ambitious, became a victim of continuous budget cuts resulting from a declining defense budget, expensive wars in both Iraq and Afghanistan, and the unexpected costs of assisting the Gulf area after Hurricane Katrina. In response to the declining budgets, the program sacrificed schedule, extending dates for initial operational capability further and further into the future. At the same time, the focus on conventional warfare against large nation-states dwindled and spending on counter-terrorism and irregular warfare increased. Since the program was cancelled, many of the sub-programs under FCS have been spun off into other capabilities.[102]

GBU-28 Bunker Buster

The GBU-28 Bunker Buster was developed in 1991 to target underground hardened Iraqi command centers during Operation Desert Storm. The GBU-28 Bunker Buster was developed by modifying off-the-shelf products and can penetrate 100 feet of earth and 20 feet of concrete. The program is unique because the total development time was approximately one month from system conception, design, fabrication, testing, and deployment.[103]

101. Wikipedia.org. http://en.wikipedia.org/wiki/Future_Combat_Systems
102. Globalsecurity.org, Military. http://www.globalsecurity.org/military/systems/ground/fcs.htm
103. Wikipedia.org. http://en.wikipedia.org/wiki/GBU-28

History

Intelligence in early 1991 revealed deeply buried Iraqi command centers. An analysis of alternatives considered potential solutions to neutralize these command centers, and the selected solution was a heavyweight laser-guided bomb dropped from a high altitude, with a supersonic impact and hard body. This bomb was to be produced using off-the shelf components readily available to the military. On February 7 of the same year, the configuration was set for the bomb. It was to be compatible with both the F-111 and F-15, use the Howitzer gun barrel for a body, and have a modified GBU-24 guidance kit. The result was a 13-foot long bomb, weighing 4,700 pounds with a 630-pound Tritonal explosive and delayed fuse. On February 13 the "Go" decision was given to produce these bombs and on February 16, the first bomb body was constructed and delivered to Eglin Air Force Base. The first captive flight clearance testing was done between February 18 through 22, less than a week after the original production decision. By February 24, testing at Tonopah Test Range Airport resulted in one drop without explosive achieving a penetration of greater than 100 feet of earth. The Holloman rocket sled testing, done on the same day, resulted in the explosive penetrating more than 22 feet of steel reinforced concrete. By February 27, two systems had been sent to Saudi Arabia with the final destination of Iraq. Two bombs were dropped on February 27 at an underground Iraqi command center. One had a direct hit. The Iraqi cease-fire was declared on February 28, about two weeks after the conception of the GBU-28.

Differentiating Characteristics

The GBU-28 program was unique in that it went from conception to active service in approximately one month. This success was based on the fact that everyone involved, the Air Force, government agencies, and support contractors, were wholly focused on the task at hand and operated in an empowered team structure. The program had the support of Air Force leadership and there was an excellent relationship with the contractors and other government support organizations. The development strategy was parallel with the analysis of alternatives, allowing a more rapid decision on the selected solutions. The bureaucracy was excluded from the process and the program was conducted solely by operators and engineers.

The bottom line was that everyone involved on the small, focused team knew what the customer needed and they would not accept non-value added tasks or

bureaucratic delays. Their skill, courage, and confidence turned a seemly impossible task into a very successful program.

IT Box

The Joint Capabilities Integration Development System (JCIDS) "IT Box" was formally indoctrinated by the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6212.01D, Interoperability and Supportability of Information Technology and National Security Systems. This instruction implemented a formal process for integrating information technology across all military departments so that they are interoperable within the DOD and allow for the rapid incorporation of evolving technologies.[104]

History

The IT Box program was created from a Joint Requirements Oversight Council (JROC) desire that IT programs have the flexibility to plan for and incorporate evolving technology. This program streamlines the JCIDS process for military departments and agencies developing new IT projects or programs. Therefore, threshold capability levels are based on what is achievable with today's technology. The CJCSI 6212.01D delegated authority for moving beyond the above thresholds by utilizing technology refresh. It also provides a level of effort funding for software development.

Differentiating Characteristics

The IT Box program was established to reduce trips to the JROC for approval of improved capabilities, and reduce the time to field an improved technology. The doctrine provides for inclusion of the Functional Capabilities Board, Joint Capabilities Board, and JROC as participants in the approval process for an IT program Capability Development Document (CDD). Once the CDD is approved, there is no need for the program office to return to the JROC with a Capabilities Production Document, unless the Milestone Decision Authority requires JROC approval. These conditions only apply to programs that do not need to develop hardware, but are leveraging COTS hardware.

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104. CJCSI 6212.01E. http://www.dtic.mil/cjcs_directives/cdata/unlimit/6212_01.pdf

Stryker

The Stryker Light Armored Vehicle III (LAV III) is meant to provide a balance between power and mobility that heavier armed vehicles cannot provide. The goal is for the Stryker to be as deadly as a tank, as swift as a HMMWV (high mobility multi-purpose wheeled vehicle), and able to mobilize anywhere in the world within 96 hours.[105] The Stryker LAV III is meant to be the centerpiece of the Army's new Stryker Brigade Combat Teams.

History

The Stryker vehicle is part of the Army's transformation goals to deploy brigade combat teams within 96 hours, a division within 120 hours, and five divisions within 30 days. The vehicle is required to be deployable by C-130 and larger aircraft, and to weigh no more than 19 tons. The vehicles have a maximum speed of 60 miles per hour and a range of 300 miles on a tank of gas. They will give the new Brigade Combat Teams a smaller logistical footprint by using common equipment across the entire line of Stryker vehicles, as well as using common equipment to other medium tactical vehicles deployed by the Army. It is estimated that the new Stryker Brigade Combat Teams will be 25 percent cheaper to operate than the previous heavy brigades. The contract was awarded to GM GDLS in November 2000, which is a joint venture between General Motors' Electro-Motive Division and General Dynamics' Land Systems Division.[106] Most of the work is done in Sterling Heights, Michigan, and other sites in the United States and Canada, as well as some final assembly at government sites, such as Fort Lewis in Washington.

Differentiating Characteristics

The Stryker vehicle was fielded within four years of its concept phase. The process began with a competitive evaluation of current platforms to define vehicle requirements and help to shape a request for proposal (RFP). Training

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105. "How Strykers Work," Howstuffworks.com.
http://science.howstuffworks.com/stryker.htm/printable
106. Globalsecurity.org, Military.
http://www.globalsecurity.org/military/systems/ground/iav.htm

and CONOPS development were done with "look-alike" vehicles before production began on the real Stryker vehicles. Simulations were used to configure each Stryker variant. Production of all Stryker vehicles took place in a combination of industry and government facilities. Finally, the contract called for contractor support for the first two years of active Stryker vehicles with transition to government support as needed.

VH-71 Kestrel Presidential Helicopter

The VH-71 Kestrel was a helicopter being developed by Lockheed Martin Systems Integration-Owego, AgustaWestland, and Bell Helicopter, known as the "US101 Team." The helicopter was to replace the U.S. Marine Corps One Presidential transport fleet. In 2009, the U.S. Navy terminated the project and reinvested the funds to upgrade the existing fleet.

History

Development began on the VH-71 Kestrel in 2002 when Lockheed Martin and AgustaWestland partnered to develop a medium-lift helicopter for the President in response to lessons learned on 9/11. In 2003, DOD issued a request for proposals for 23 new helicopters to replace the current Presidential transport fleet. The helicopter developed by Lockheed Martin and AgustaWestland received the initial $1.7 billion dollar contract in 2005.

The engineering challenges were steep and delays plagued the development of the VH-71 Kestrel. Over the next four years the price of development continued to increase to an estimated total of over $13 billion in 2009. Poor communication within both the contractor team (between the prime and the subcontractors) and the government team (between the Navy PEO, the Marines, and the White House) contributed to epic levels of finger pointing. For example, the US101 team has faulted the government for insisting on extensive modifications not included in the original RFP as a cause of cost overruns. In 2009, the U.S. Navy finally terminated the contract with the US101 team.

Differentiating Characteristics

The significant cost overruns of the VH-71 Kestrel program ultimately resulted in the contract's termination. The DOD recommended as early as 2007 to terminate the program, but was overruled by the White House. In 2008, in the lead up to the presidential election, Under Secretary of Defense for Acquisition, Technology, and Logistics John Young stated that the VH-71 was very high on the list of programs to be cut by the Obama administration. Later, at a White House gathering, President Obama stated that the procurement process had "gone amok and we are going to have to fix it." He then stated, "The helicopter I have now seems perfectly adequate to me." In the spring of 2009, Secretary of Defense Gates cancelled funding for the VH-71 and the contract was formally terminated by the U.S. Navy in June 2009.[107]

107. Wikipedia.org. http://en.wikipedia.org/wiki/Lockheed_Martin_VH-71_Kestrel

Appendix B. Enhancing Adaptability of Military Forces: The Foreign Language Experience[108]

> "The ability to innovate in peacetime and adapt during wars requires individual and institutional agility"
>
> *2010 Joint Operating Environment (p. 72)*

> "… the United States needs a broad portfolio of military capabilities with maximum versatility across the broadest possible spectrum of conflict. Toward this end, the Department must continue to reform the way it does business – from developing and buying major weapon systems to managing our workforce." (emphasis added)
>
> *Robert M. Gates, Secretary of Defense*
> *2010 Quadrennial Defense Review*

> *(Shortly after the commencement of Operation Iraqi Freedom, I was performing Temporary Duty at Fort Bragg, North Carolina. About midnight, my Blackberry buzzed. It was a message from Baghdad: "Could you please send Arabic speakers?" I knew there were none to send…)*

Since the onset of military operations following the terrorist attacks of September 11, 2001, it has become apparent that the United States is engaged in conflict and operations that demand skills beyond those required for conventional warfare. Post-conflict stability operations, "nation building," building partnership capacity, strengthening relationships, expanding allies and partners, counterinsurgency, irregular warfare—these are terms that connote the need to understand the language, culture, and rules that others, with whom we find ourselves engaged, live by. Failure to understand can cause mission failure, or, more commonly, opportunity lost.

At the start of Operation Iraqi Freedom, the Department embedded journalists with the forces advancing to Baghdad. Embedding linguists within those same forces could have had effects that changed the eventual course of the conflict. The opportunity lost in not being able to communicate with the population around us is

108. The author of this appendix, Gail H. McGinn, is the former (retired) Deputy Under Secretary of Defense for Plans in the Office of the Under Secretary of Defense for Personnel and Readiness and Department of Defense Senior Language Authority from May 2004–May 2010.

rarely calculated, but it is significant. The House Armed Services Committee Subcommittee on Oversight and Investigations (HASC O&I) conducted an in-depth study of language skills and cultural competencies in the military. The subcommittee concluded:

> "The Coalition Forces' experiences in Iraq demonstrate the significant military requirement for foreign language and cultural expertise across the full spectrum of operations. In the first year of operations, the ready availability of Arabic language skills almost certainly would have better positioned commanders to take fuller advantage of important intelligence from captured prisoners and documents that might have identified earlier the potential for the emergence of an insurgency. And importantly, with language skills and cultural awareness, the coalition could have better communicated its positive intentions, throughout its operations, directly to the population, thereby making its counterinsurgency efforts much more effective." (HASC O&I Report, 2008, p. 53.)[109]

Since 2001 the leaders of the Defense Department have increasingly recognized the importance of developing forces with this understanding, and developing leaders who can not only lead to victory in conventional battles, but also lead to victory in engagements that prevent these battles and "win the peace" following military operations.

Thus, a key focus from 2001 to the present time has been an effort to transform the way the Department values, develops, and employs foreign language expertise. This effort has been captured in the Department's *Defense Language Transformation Roadmap*. In the years since the roadmap's publication (in February 2005), the Department has made remarkable progress. For example, the entire force has been surveyed, identifying unknown language talent. The Defense Language Institute Foreign Language Center (DLIFLC) has been reinvigorated with a budget growth from $77 million in fiscal year 2001 to $270 million in fiscal year 2008 (McGinn 2008, p. 15). DLIFLC has refocused on languages of strategic importance and has fielded hundreds of mobile training teams to installations for pre-deployment language instruction. Language testing programs have been upgraded and

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109. The HASC O&I further noted the importance of this capability: "Today's military establishment, its active duty, reserve, and civilian personnel, must be trained and ready to engage the world with an appreciation of diverse cultures and to communicate directly with local populations. These skills save lives. They can save lives when the military is performing traditional combat missions, just as they are recognized as critical for performing irregular warfare missions. They can save the lives of our personnel and can greatly reduce the risk to the indigenous, non-combatant populations that the military may be trying to protect or win over. Speaking the language with an appreciation of local culture is a potent tool in influencing a mission's outcome in our favor." (HASC O&I Report, 2008, p. 9.)

modernized and new financial incentives have been put in place for those with ability in foreign languages. A tremendous capability has been built. But all the hurdles have not been topped, and this experience might be informative to a debate about what appears to be the overall problem statement: *"When on-going operations demonstrate the need for a new competency, how do you embed it quickly in the force? How do you achieve the individual and institutional agility needed for future success?"*

A number of factors impede the accomplishment of adaptability objectives. Institutional processes slow change and favor the status quo, cultural issues abound, skepticism also arises—such as the traditional suspicion about "is this just the flavor of the month?," doctrinal change must be embraced, and those who embrace change must be rewarded. To a large degree, change depends upon the experience of commanders in the field. When they return with lessons learned revealing the need for a capability such as understanding languages and culture, things do start to change. The only problem is that, by then, years have passed.

In the Beginning

The Defense Language Transformation journey began in 2002, when then-Secretary of Defense Rumsfeld asked that the Under Secretary of Defense for Personnel and Readiness "get a template of what we think the most important languages are going to be, set some targets, and then tell the Services to get about it."[110] Within the under secretary's office, the responsibility fell to me as the Deputy Under Secretary for Plans. In November 2002, we asked the combatant commands, the military Services, and the defense agencies to describe their foreign language requirements. The response was a set of "narrowly scoped requirements based upon their current manning authorizations instead of requirements based upon recent operational experience and projected needs."[111] There appeared to be a fear that if new requirements were identified, they would be forced to take them "out of hide" and reduce manning elsewhere. This would be the first indication of a nagging problem that would bedevil the effort over the ensuing eight years.

At about this time, I encountered a set of future colleagues desperate for a fix to the Department's foreign language failings. Many had labored long in this endeavor and they were frustrated by the institution's failure to embrace this critical skill. The title of the briefing they offered was, "Foreign Language Program: Leadership wanted." These impressive individuals were remnants of a senior oversight

110. Secretary of Defense. "Snowflake," October 1, 2002.
111. Defense Language Transformation Roadmap, 2005, p. 1.

committee that had fallen by the wayside, leaving them to try to make things happen on their own. To their credit, they did succeed in keeping the issue alive (or at least on life support) and formed an experience base that was essential to the development of the path forward.

Their briefing highlighted an immediate problem. The policy and program governance was outdated. The Defense Language Program Directive current at that time dated from 1988 and assigned responsibilities to offices that no longer existed. The Under Secretary for Policy had an interest, the Under Secretary for Intelligence had an interest, and the Under Secretary for Personnel and Readiness had an interest. No one was clearly operating as the lead agent—certainly not at the senior level.

The Department's language schoolhouse, the Defense Language Institute Foreign Language Center had been ignored. It was under-funded, had outdated curriculum and proficiency tests, and, most egregiously, had a few hundred "hold-unders"—students in waiting who couldn't start school because of funding shortfalls. A review of DLIFLC commissioned by the Under Secretary of Defense for Personnel and Readiness documented 450 students awaiting instruction in November 2003 (Smith 2003, p. 19).

Who Wanted Change?

The most remarkable attribute of the Defense Language Transformation effort was the senior leader involvement. It was literally driven by the Secretary and Deputy Secretary of Defense (Secretary Rumsfeld and Deputy Secretary Wolfowitz at the time[112]). Through words and directions given in the course of their years, it was clear that they saw the need for teaching more of the right languages, instilling language capability in the officer corps, and enhancing the Foreign Area Officer Program.[113] The Secretary of Defense issued at least 25 "snowflakes"[114] on this topic. Clearly, the most senior defense leadership saw language transformation as a priority.

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112. "In addition, Deputy Secretary Gordon England subsequently included strengthening foreign language and cultural awareness capabilities among the Department's top 25 transformation priorities." HASC O&I, 2008, p. 20.
113. Foreign area officers are officers highly skilled in the language, culture and regional affairs of designated parts of the world. See DOD Directive 1315.17, April 28, 2005, "Military Department Foreign Area Officer Programs."
114. "Snowflakes" were memos issued by Secretary Rumsfeld, often prescribing guidance for principals on important issues.

First Steps

From a policy and bureaucratic perspective, we needed to fix governance. We updated directives and instructions. In an effort to reengage senior officials in the language issue, the Deputy Secretary issued guidance on May 10, 2004 to establish Senior Language Authorities at all combatant commands, the military Services and defense agencies. These Senior Language Authorities would be senior executive or general/flag officer leaders and would comprise a Defense Language Steering Committee. The steering committee would be responsible for guiding the Department's efforts in language transformation and management.

The Senior Language Authority concept was adopted from a successful model at the National Security Agency. A senior executive was responsible for knowing everything about language requirements in the component: needs, capability, and issues. The Deputy Under Secretary of Defense for Plans was appointed as the DOD Senior Language Authority. Components were left to decide their own best executive to be appointed to this position.

Knowing from experience that even though senior leadership gave direction, those who seek to implement the guidance might need further substantiation. A second major step was to initiate a research effort. In September 2003 an independent contractor was engaged to study and provide advice on key critical issues.[115] As noted in the *Defense Language Transformation Roadmap*, the studies provided a foundation for development of the roadmap. At the same time we commissioned an *ad hoc* Language Transformation Team with representatives from the military departments, defense agencies and Special Operations Command to conduct further reviews and recommend actions.

With senior leadership guidance, a governance structure in place, and a foundation underway in research, a final requirement was to get a hook in the Department's strategic guidance for the future. This would drive funding and Departmental action. Indeed, the *Strategic Planning Guidance* for FY2006–2011 created critical bedrock for efforts to come and directed the development of the *Defense Language Transformation Roadmap*.

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115. The *Defense Language Transformation Roadmap* notes that these studies were: Language Management within the Combatant Commands, Management of Foreign Area Officers within the Services, Development of Foreign Language and Regional Knowledge in the Officer Corps, Management of Language Personnel, and Requirements Determination Processes for Assessing Language Needs.

Engaging Senior Leaders

To engage transformation, we considered it critical that work remain focused at the senior executive/general/flag officer level. Remembering the experience of the past, the Defense Language Steering Committee held to a rule that only those senior individuals appointed as Senior Language Authorities would be seated at the table for deliberations.[116]

The Defense Language Steering Committee developed and agreed upon the assumptions, goals, and tasks of the *Defense Language Transformation Roadmap*. From June through August 2004, the committee worked on the roadmap and approved it on August 31. The roadmap was then submitted to the Department as a whole for coordination, and was fully agreed to and subsequently approved by the Deputy Secretary and issued in February 2005.

In approving the roadmap, the Deputy Secretary added words to enhance language instruction for junior officers and to highlight foreign language as a criterion for advancement to general officer. These added emphases later became a lightning rod for opposition to foreign language acquisition, and, unfortunately, by extension to the roadmap itself.

The Defense Language Transformation Roadmap

The centerpiece of the language transformation effort was the *Defense Language Transformation Roadmap*. This roadmap articulated underlying assumptions, agreed upon goals, and 43 specific actions designed to accomplish the identified goals. The principal goals, derived from guidance articulated in the *Strategic Planning Guidance*, were:

- First, create foundational language and regional expertise.
- Second, understand that we could not produce all the capability required within the force, we needed to create the capacity to surge.
- Third, value and establish a cadre of language professionals possessing the highest levels of proficiency in reading, listening, and speaking a foreign language—at level three in the Interagency Language Roundtable proficiency scale.[117]

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116. In normal practice, principals would be allowed to delegate their attendance to staff.
117. The Interagency Language Roundtable has created a scale for rating language proficiency from levels 0-5. The scale is widely used by federal agencies for describing individual proficiency. Level 3 is considered to be General Professional Proficiency. See http://www.govtilr.org for more information.

- Finally, protect DOD's investment in language professionals and foreign area officers by tracking their accession, separation, and promotion rates.

With the exception of interests of the Deputy Secretary of Defense for officers with language expertise and language expertise as a criterion for advancement to general officer (added after departmental coordination), the roadmap actions were agreed to by the Department as a whole. The controversy created by the requirement for officer language acquisition and, in particular, general officer language competence eventually required that the importance of the roadmap and our efforts be re-validated during the development of the *2006 Quadrennial Defense Review (QDR)*. In the end, after much debate, the 2006 QDR did re-validate the effort and dramatically expand the Department's effort and funding for language initiatives. The QDR recognized that: "Developing broader linguistic capability and cultural understanding is also critical to prevail in the long war and to meet 21st century challenges. The Department must dramatically increase the number of personnel proficient in key languages such as Arabic, Farsi, and Chinese, and make these languages available at all levels of action and decision—from the strategic to the tactical."[118]

The QDR specifically provided funding to:[119]

- Support the Army's pilot linguist program. The Army had initiated a special program to recruit heritage speakers of Arabic, Dari, and Pashto and developed a special cadre of "09L Interpreters and Translators." These soldiers became very popular with commanders and brought high-level language skills to support operations.[120]
- Require language training for Service Academy and Reserve Officer Training Corps scholarship students.
- Increase military special pay for foreign language proficiency.
- Modify tactical and operational plans to improve language and regional training prior to deployments.
- Increase National Security Education Program grants to American elementary, secondary, and post-secondary education programs.

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118. *2006 Quadrennial Defense Review Report*, p. 78.
119. *2006 Quadrennial Defense Review Report*, p. 78–79.
120. About 1,000 soldiers recruited to be 09Ls have served or are serving in theater. This concept has been augmented by a program entitled "Military Accessions Vital to National Interest." Through this program the Army, Navy, and Air Force recruit heritage speakers who are legal non-citizens, and who have skills required to be linguists and health care professionals (Weaver 2010, p. 7).

- Establish a Civilian Linguist Reserve Corps to provide an on-call cadre of high proficiency, civilian language professionals to support the Department's evolving operational needs.[121]

From Here on it Should Be Easy

At this point in February 2006, we had published the roadmap, reconfirmed the Department's commitment to the development of a foreign language capability, and secured funding to ensure the success of identified initiatives.

And indeed, remarkable progress was made.

Foundational Expertise

The Joint Staff issued guidance as to how to articulate foreign language requirements and prompted those requirements to be reported regularly.[122] Unlike the data call issued in 2002, these were unconstrained requirements developed in an effort to size the capability need. Indeed, we identified about 140,000 unconstrained requirements. However, in spite of the guidance, we found that the various combatant commands were using different approaches to developing requirements. None of the approaches were wrong, they were just not consistent. Other than giving us a look at potential needs, we were unable to use the requirements generated as a signal for the military departments to use in training and developing individuals in the force—critical for the development of foundational expertise. These were *ad hoc* requirements, not generated within systems acceptable and recognized for force development by the military services.

For the first time, the Department set out to document the current capability in the force. Each Service conducted surveys of all members to determine their proficiencies in languages other than English. The surveys identified about 300,000 DOD members with language skills. As one might surmise, most were French, German, and Spanish, but a remarkable number of strategic languages were found—such as native languages of Africa. This provides a powerful on-call capability for the Department, used to great effect by the Department of the Navy. Service members are tested to validate their proficiency as they are needed.

We developed a Language Readiness Index, as a part of the Defense Readiness Reporting System that can match assets to operational need.

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121. Based upon market research during program development, the name of this program has been changed to the National Language Service Corps.
122. See the Chairman of the Joint Chiefs of Staff Instruction 3126.01, "Language and Regional Expertise Planning," January 2006

To encourage the study of foreign language in the Reserve Officer Training Corps (ROTC), we successfully advocated and, with the help of the Congress, processed a legislative change to allow us to provide a stipend for the study of strategic languages. We also provided grants to ROTC institutions to create pilot programs for ROTC language study.

We worked with the Service academies to increase language study up to four semesters for cadets/midshipmen, including enhanced study abroad opportunity. Exceptions were made for technical majors in areas such as science, math, and engineering.[123]

And we greatly enhanced the Defense Language Institute Foreign Language Center—increasing student throughput from 1,900 students in 2001 to 4,000 today, raising the bar on graduation proficiency, and improving curriculum and testing.

Surge Capability

At the start of Operation Iraqi Freedom, the Under Secretary of Defense for Personnel and Readiness asked the commandant of the DLIFLC to develop a pre-deployment course for troops en route to Iraq. DLIFLC obliged, and the course was offered to the military services. At that time, there was no interest in pre-deployment training targeted to foreign language acquisition. As a sign of changed times and understanding of the importance of language and cultural expertise, pre-deployment training in languages and culture is now routine. DLIFLC dispatches mobile training teams for this purpose, and indeed has conducted over 440 training missions, reaching 118,000 members. DLIFLC has also developed language survival kits—more than 1.5 million in 37 languages.

DLIFLC has also developed on-the-shelf curricula and materials for emerging languages and dialects. In early discussions with DLIFLC, leadership noted the absence of guidance about what parts of the world they should focus on for planning purposes. As required in the roadmap, the Department developed a Strategic

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123. There is an enduring conflict between the need to teach foreign language and the perceived need for technical majors to focus exclusively on their technical coursework. This conflict reflects a larger national issue—we need to encourage students to study science, technology, engineering, and math in order to maintain our global competitiveness in those areas. At the same time, we need a culturally savvy workforce capable of engaging with foreign concerns. In reality, these aims may not be mutually exclusive. The Department's higher education Flagship program provides grants to universities in order to graduate students with high-level language proficiency in a variety of disciplines including technical study. The success of those institutions is one proof that the nation can pursue both goals.

Language List based on defense and national strategic documents. DLIFLC now has materials for about 20 emerging languages, with 17 more in development.

The Department also consolidated its contracted linguist effort under the Army as executive agent to reduce competition and maximize efficiency.

High Proficiency/Foreign Area Officers

The Defense Language Proficiency Test was old, memorized, and compromised. The Department improved the testing program and created the Defense Language Proficiency Test 5. This test is web-based, uses authentic materials, and is much more capable of determining actual proficiency in the higher levels.

Foreign Language Proficiency Pay was increased up to $1,000 per month for high-level proficiency in the strategic languages.

The Department has increased documented requirements for foreign area officers (FAOs). In FY2001, there were about 1,000 FAOs in the Army and Marine Corps (McGinn 2008, p. 21). Today are over 1,860 FAOs in the Army, Marine Corps, Air Force, and Navy (Weaver 2010, p. 11).

These are examples. Through Herculean efforts in the military services, the defense agencies, and the combatant commands, almost all of the actions in the roadmap have been accomplished. But work remains to be done, and this work may be emblematic of the difficulties inherent in expecting agility in the Department for human capability.

What Hasn't Been Accomplished?

Two major initiatives remain undone. As noted earlier, from the very beginning leadership wanted language competency in the officer corps. The roadmap language states:

1. Establish the requirement that junior officers complete language training. Make available one-year assignments for junior officers to serve with a foreign or national constabulary/para-military force and reward such service via advancement.
2. Make foreign language ability a criterion for general/flag officer advancement.[124]

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124. *Defense Language Transformation Roadmap*, 2005, pp. 7-8.

The Department never embraced these roadmap requirements. In fact, the issue of language competency in the officer corps became quite emotional and heated. While senior leadership clearly found value in having leaders who could engage with leaders of foreign countries or with indigenous populations, others found this a bridge too far—doubting that everyone had the ability to learn another language and concerned about how to fit language instruction into an officer's career. A follow-on issue was how the individuals who had this expertise would be used. To a great degree, to make use of the capability would mean a change in the way forces, units, and individuals are deployed, a step the military services appeared to be reluctant to take in order to accommodate the need for language and cultural competency.[125]

The second bit of unfinished business involves the need to quantify the foundational language requirement in order to send the military departments the signal required to develop the required forces with the right skills. For the *competency* of foreign language, there was no clear traditional signal to the military services communicating what they needed to grow in the force. As noted earlier, previous efforts to engage in a requirements review from the combatant commands were *ad hoc* (although agreed to by the Departments), and did not satisfy this need.[126]

Without solving the "requirements" issue, under current practices the Department will never confront the need to develop the foundational foreign language competency essential to initial operational engagements and continuing relationships.

What Were the Roadblocks?

Clearly progress was made and that progress cannot be overstated. Nonetheless, along the way and, in some cases, existing still today, systemic, doctrinal, cultural, and even societal roadblocks inhibited the Department's ability to respond with all due haste to adapt to the critical operational need for foreign language capability. The lessons learned in this context can translate into others—the particular issue here is that the Department needed to develop a competency in its people. If the requirement had been to develop skills to operate new hardware or weapons platforms, or execute cyber security, the Department could have responded.

125. As stated earlier, the 2006 QDR did endorse language training for officers pre-accession in the academies and in ROTC. The question remaining is how the Department will use and nurture the language skills acquired by these young leaders.
126. The Department is currently engaged in a capabilities-based assessment led by the Joint Staff in an effort to resolve this issue (Weaver 2010, p. 4).

Discrete requirements would be set, driving schoolhouse seats and professional development. In this case, the requirement for an internal competency such as foreign language and an understanding of cross-cultural issues is a capability, like leadership, that needs to be a part of every service member's development, officer and enlisted alike.

Systemic Issues

Institutional personnel and manpower systems could not deal with undefined requirements reflecting a need for a capability. The military departments have processes for requirements determination. Billets need to be documented as requiring a skill in order for the system to respond by growing people with those skills. In the case of foreign language, the skill might be secondary to a primary specialty, but critical nonetheless. (Military police manning roadblocks are an example in point.) For example, early in the transformation effort it was clear that combatant commands were not requesting FAOs because the need could not be met and they risked having billets unfilled. Therefore, no signal was sent to the military departments requesting an increase in FAOs. Because no signal was sent, no FAOs were produced—a vicious cycle leading to unavailable capability.

In addition, the need for language capability was not included in normal demand signals. Because the contracted linguists for Operation Iraqi Freedom and Operation Enduring Freedom were not documented billets, the system never got the official signal that there was a requirement for these skills. Indeed, the processes driving the student load at the DLIFLC do not account for broader capability needs. As a rule, each seat is filled by someone destined for a documented billet (mostly intelligence). An examination of student load will no doubt find a mismatch between current operational needs and class fill.

Ultimately, there is no formalized joint process for assessing the human capability needs of the combatant commanders in a timely way, and, based upon that process and its analysis, developing a program that directs the military services to grow that human capability.

Doctrinal Issues

The need for a critical competency in personnel needs to be reflected in military doctrine. Language competency is not clearly articulated in doctrinal documents. While this was called for in the roadmap, the HASC O&I investigation into the

Department's efforts demonstrated that the Department had not yet accomplished this end: "In 2006, the Department reviewed the Services' doctrine, policies, and guidance to determine whether they identified or treated foreign language skills and cultural awareness as core competencies. It found few instances where doctrine, policy, or guidance addressed or even mentioned that these skills were core competencies, although the analysis did note that many of these publications were in the process of being updated" (HASC O&I Report, 2008, p. 30).

The key issue, to be addressed in doctrine for adaptability, is whether the way the Department assigns forces is conducive to the rapid import of a capability such as foreign language into those who are deploying. In addition, and most importantly, is there deliberate planning for the use of such forces in the future? Or is this a lesson to be learned and forgotten?[127]

Cultural Issues

What gets said within a culture is emblematic of the values of that culture. During the six-year language transformation effort, certain phrases recurred in discussions, both formal and informal. Among them:

- "It is an enlisted skill." This reflects a view that an officer should have at his or her side an enlisted interpreter, much like they might be assigned a driver. Of course, this ignores the fact that leader-to-leader conversation within other cultures might be a critical way to avoid opportunity lost.
- "We can hire contractors for this." The Department will probably always require contracted linguists to provide the intense surge capacity required for operations. However, contractors do not provide the foundational expertise required for the start of operations or the leadership status necessary for communications with foreign leaders. Clearances can often be a problem. Contractors cannot be ordered into battle. Finally, without some language ability, it is difficult to ensure that contracted linguists are correctly expressing words and thoughts.
- "Machines can do it. Invest in technology." Yes, it is important to invest in technology. But the search for the "universal translator" continues. Technological solutions need to be tailored to specific situations and may, in

127. The Afghanistan-Pakistan Hands model currently being employed by the Department, targeting individuals for language study and deploying them strategically in theater, is an important development in this regard. For more information, see *2010 Quadrennial Defense Review Report,* p. 25.

fact, lead to a requirement for more human beings who can check technology's work. We aren't there yet.

- "We can't be absolutely certain about this." This translates into: we don't know exactly what language might come along next, so any investment might be wasted. Implicit is this statement is the view that the appropriate action, therefore, is to do nothing.
- "Let's get this perfectly right." Related to the statement above, this implies that risk is unacceptable. These two statements together appeared to be designed to slow the effort down.
- "We don't have people with those languages, so we don't ask for them." As noted earlier, this is the circular logic that never expresses demand in a way that can be addressed by the force providers.
- "I don't have that competency, and I made it." This is the most difficult and heartfelt of comments. Obviously, the leaders who had been promoted to colonel/general/flag officer did indeed succeed in their career. However, the unanswered questions remain: what was the opportunity lost in the lack of language capability? And, is there something different today that makes success in the past insufficient for today's operations (or tomorrow's)?

Societal Issues

To some degree, the acceptance of foreign language as a critical competency in the armed forces is related to the way our nation, as a whole, values language education. We are an insular society, surrounded by water and allies, and historically not required to engage with other nations in their languages. Many believe that English is the language of the world and that our need to communicate in other tongues is limited.[128]

Early in the Department's language transformation effort it became clear that if we wanted a force with language capability, it would be helpful if we could recruit and enlist members who already had language skills. Unfortunately, foreign language instruction is undervalued in the United States and particularly in those languages of importance to the Department of Defense. Because it is undervalued, it

128. As one who has traveled the back roads of France and Germany, purported to be entirely English speaking nations, I can assure the reader that the population's English proficiency cannot be taken for granted. I also note that a minimal expression of greetings or gratitude in the foreign tongue can have a great impact on relationships.

is less available and also less desirable. This perceived lack of importance can affect the degree to which members of the Armed Forces embrace language acquisition.

The Department challenged the nation to address this issue. In June 2004, the Department, in conjunction with the Center for the Advanced Study of Language at the University of Maryland, convened the National Language Conference. This conference gathered federal agencies, business, education officials, language agencies, academia, and experts from countries that routinely teach their populace more than one language for a national conversation about foreign language needs.

The National Language Conference resulted in a white paper entitled *A Call to Action for National Foreign Language Capabilities*, published in February 2005. Among other things, the white paper recommended designation of a National Language Authority to "develop and implement a national foreign language strategy" and a "National Foreign Language Coordination Council to coordinate implementation of the national foreign language strategy."[129]

Subsequent to the publication of the white paper, a number of legislative initiatives to create a national foreign language coordination council surfaced in congressional language but were not enacted. Additionally, the Department of Defense joined with the Department of State, Department of Education, and the Director of National Intelligence to launch the National Security Language Initiative (NSLI). This initiative was intended to spur the development of educational programs that would create graduates with high-level proficiency in languages important to national security. The NSLI was announced by President Bush in January 2006. The Department of Education never received the appropriation of the robust funding requested to fully implement their NSLI initiatives.

The Department of Defense is continuing its efforts to spur a national agenda, and engaged three states (Texas, Oregon, and Ohio) in the development of their own roadmaps. NSLI activity is still underway, but now the nation's schools face funding shortfalls that threaten foreign language education.

Could It Have Been Different?

There are those who have remarked, with justification, that the Department reacted to the need for foreign language capability, but did not react quickly enough. As noted above, the ability to embed a competency in the force and field it rapidly is

129. *A Call to Action for National Foreign Language Capabilities*, 2005, p. iii.

challenging. The systems that drive change in this regard are slow moving, as if they are designed to default to the status quo.

The Department could have done the following. Immediately, upon planning for operations in Afghanistan and Iraq, we could have included in that planning pre-deployment training in the languages and cultures of the regions. Linguists (either within the Department or hired from the civilian community[130]) could have been embedded with advancing forces. We could have identified those in the force (active duty, reserve, and civilian) with proficiency in the languages of those regions and built upon that proficiency—providing training and employing them without regard to service or military occupational specialty (or civilian equivalent). In addition, the military services could have identified 50-100 service members (enlisted and officers) per year within the general purpose forces to attend training at the Defense Language Institute Foreign Language Center to provide a base of language support for the future. Investments in reachback capability for interpretation and translation could have been made and service members equipped with cell phones would have been able to access language support. Recruiting programs such as the Army's 09L heritage recruiting could have begun immediately.

For the longer term, officers and senior enlisted personnel could be prepared, through professional military education and individual study, to engage knowledgably in targeted areas of the world. Doctrine could address how these skills will be employed in all phases of deployments and operations. And to set the stage for future operations, the Department could change the culture by deliberately developing a cadre of officers who can communicate in the languages of the world and by embracing the roadmap's goals of foreign language as a criterion for promotion to general/flag officer.[131]

The *2010 Quadrennial Defense Review Report* promises continued investment in this capability (see pp. 29-30). However, the ultimate lesson learned for adaptability in human capability is that the groundwork must be laid in advance. Trust must be placed in senior leaders who see, from their perspective, the changes that must be made. And these changes must be made, even though our existing systems and processes have not caught up.

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130. The National Language Service Corps should be a model for this.
131. The stage for this is set with the educational initiatives at the military service academies and within ROTC. I know from conversations with cadets at West Point that our future officers are willing to rise to this challenge.

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Appendix C. Open Architecture Systems

Characteristics of an Open Architecture

It is important to define what is meant by open architecture and provide some guidelines for consideration when specifying and procuring open architecture systems. Table C-1 lists the key characteristics of open systems, which are described further in the remainder of this appendix.

Table C-1. Characteristics of an Open Architecture

Characteristic	Open Systems	Remarks
Decoupled hardware and software	Hardware and software can be changed independently of each other.	Decoupled hardware and software enables the owner of the system to easily upgrade the hardware and software.
Decoupled software modules	Software components have modularly defined functionality.	Defined modular functionality allows the owner of the system to quickly introduce new capabilities.
Defined data model	Data contents and meaning defined and published in a model.	Defined data models simplify the process for adding new capabilities into the system.
Interface definition	The hallmark of an open system is the definition of the various interfaces of the system.	Open systems only work if their interfaces are defined and available. Interface should be non-proprietary and owned by the customer.
Standards	Use government or industry defined and controlled standards.	Choosing the correct set of standards is highly dependent upon the environment in which the system operates.
Life cycle development models	Can use any life cycle development model—works best with iterative and evolutionary models.	System owners benefit when using iterative and evolutionary models with open architecture systems.
Commercial off-the-shelf (COTS)	Embrace COTS and are designed to support the dynamic aspects of using COTS.	Open architecture systems are designed to leverage the tremendous power associated with tapping into the COTS computing world and bringing newer technologies to the field faster.
Data rights	Buyers of the system have the rights necessary to maintain the system.	Open architecture systems do not have data rights, which make it difficult to add new capabilities.

Decoupled Hardware and Software

In an open architecture system, hardware and software are decoupled. In other words, hardware and software can be changed independently, without needing modifications to the other. This is extremely important to take advantage of the system architecture and allow upgrades to be implemented quickly and at lower cost. With computing hardware significantly changing every two years, and processors becoming obsolete in less than the time in which U.S. systems are typically deployed, it is necessary to have a way of changing the hardware to keep pace with technology without incurring significant costs to modify the software. On the other side of the equation, with threats changing so quickly, the U.S. military must have the ability to change software applications to counter new threats and deliver new missions without requiring changes to the underlying hardware. Middleware is the fundamental tool that enables decoupling of hardware and software. An open architecture system must have decoupled hardware and software.

Decoupling of Different Software Components

The software components within an open architecture system must have uniquely defined and contained functionality. In other words, the software components should not have coupled functionality. You should be able to modify one software component without having to modify several of the software components within the system. Legacy systems frequently contain tightly coupled software components because of their system architectures. When a system has tightly coupled software, many components require modification in order to introduce new capabilities. The modification of multiple components complicates the problem, creates a long schedule, and costs much more money. The structure of open architecture systems enables adding new functionality to a single software component simply, quickly, and for less money.

Defining a Data Model

A data model is a recently developed technique for defining data exchange within an open architecture system. A data model identifies the structure of the data exchanged within the system. It is developed and published for use by any party responsible for developing applications for the system. By developing a data model and sharing it with all the developers, it ensures that the system will exchange data consistently among the components. A data model alleviates many of the problems

encountered in legacy system development associated with independently developed point-to-point interfaces.

Interface Definition

In addition to defining a data model, interfaces between components and the open architecture system computing infrastructure must be defined. Component-to-component interface definitions are still required to depict basic exchange of information and data flow. The data model identifies the data structures within the interfaces. The interface definitions identify the functional flow of the data. The second type of interface definitions defines the services available to the software applications within the system. For example, a typical system would provide time, data extraction, and other capabilities. These services provide application developers a list of available services to their applications.

Standards

There are several standards that identify aspects and characteristics of open architecture systems. There is no single comprehensive set of standards that address everything needed to acquire an open architecture system. To identify standards that are applicable to a particular open architecture system, it is necessary to consider the environment in which the system will operate and other systems with which it will interface. For instance, interoperability standards define data exchange within DOD systems. If a DOD system is being developed to interact with other systems, it would be appropriate to invoke a requirement to meet the DOD interoperability standards. A closed system could also be developed to meet a set of standards. A true test of openness with a system is whether or not a third-party provider can develop an application to work with the system without any assistance from the system provider. This is one way to tell if a system is both open and built to a set of standards.

Life Cycle Development Model

Open architecture system development can use any life cycle development model. Typically a user who needs an open architecture system also needs a life cycle development model that is complementary. Iterative and evolutionary development models are often chosen because of their ability to add capability rapidly and address systems that have dynamic needs. Many systems will have components that, if designed appropriately, make it possible to update system

functionality (through software updates) remotely, dramatically adding to the flexibility of the system in theater.

Use of Commercial Off-the-Shelf

Given the huge investment the commercial sector makes in improving computing power every year, open architecture system design takes advantage of using COTS. The open architecture system design with decoupled hardware and software leverages the computing power available to a user from COTS. There are several factors to consider when using COTS. In order to account for the nuances associated with COTS, strict configuration management is required. In many cases, "part A" is not the same "part A" across a set of COTS parts. It is the user's responsibility to determine what level of configuration management is needed to take advantage of COTS. The level is directly related to the tolerance designed into the system for variations in hardware.

The other thing to consider when using COTS is how quickly deployed systems can be updated. COTS products usually become obsolete more frequently than the systems DOD designs and deploy. Thus, it is important to consider how quickly a deployed system can be updated when a piece of COTS hardware embedded in the system becomes obsolete. Finally, one of the significant things to consider is the fact that DOD will most likely not be able to drive any requirements into a COTS product. Because they are off-the-shelf, these products are not customized. If a system has unique requirements, the limitations of COTS components should be considered in system design.

Data Rights

An incredibly important and often overlooked aspect to an open architecture system is what data rights the buyer will have. Systems developed on customer funding typically come with the rights. It is particularly important to ensure the interfaces are owned and controlled by the customer—without contractor proprietary data. Intellectual property at the interfaces locks a buyer into that provider and limits the ability to add third-party capabilities.

Architecture Quality Attributes

Table C-2 identifies architecture quality attributes. It is an extract from an Architecture Description Document developed by the Program Executive Office for

Integrated Warfare Systems (PEO IWS) within the Navy. The table provides an example of the type of architecture quality attributes to consider when acquiring new systems. PEO IWS recently evaluated the type of combat systems they want to acquire for the next decade. The architecture quality attributes identified are grouped by end-user impact (the ultimate operators of the system), interoperability impacts (how well the system will interact with other systems), and acquisition impacts (ability to buy new capability). These are the types of things a buyer should consider when acquiring new open architecture systems.

Table C-2. Important Open Architecture Characteristics

ARCHITECTURE QUALITY ATTRIBUTES		
End-User Impact	**Interoperability Impact**	**Acquisition Impact**
▪ Performance ▪ Availability – Reliability – Maintainability – Fault tolerance – Survivability ▪ Usability ▪ Flexibility ▪ Determinism ▪ Supportability	▪ Interoperability ▪ Backward compatibility ▪ Network-centricity	▪ Openness ▪ Reusability ▪ Affordability ▪ Testability ▪ Support incremental development ▪ Safety of software design ▪ Viability ▪ Extensibility – Scalability – Adaptability – Expandability

The PEO IWS defines "openness" as follows:

- Building **modular designs** and **disclosing data** to permit evolutionary designs, technology insertion, competitive innovation, and alternative competitive approaches from multiple qualified sources.
- **Encouraging competition and collaboration** through the development of alternative solutions and sources.
- Building **interoperable joint war fighting applications** and **ensuring secure information exchange** using common services (*e.g.*, common time reference), common war fighting applications (*e.g.*, track manager), and information assurance as intrinsic design elements.

- Identifying or developing **reusable application software** selected through open competition of "best of breed" candidates, reviewed by subject matter expert peers and based on data-driven analysis and experimentation to meet operational requirements.
- Ensuring **life cycle affordability,** including system design, development, delivery, and support, while mitigating commercial off-the-shelf obsolescence by exploiting Rapid Capability Insertion Process/Advanced Processor Build approaches.

Considerations for Open Architecture Systems

There are several fundamental considerations when setting out to acquire or develop an open architecture system. Because software and hardware functions are decoupled, there are some processing inefficiencies and added complexity in an open architecture system. There may be some limited applications where an open architecture system is not the best choice, and the recommended requirement would be waived. In order to determine whether an open architecture system is needed, it is necessary to identify the system level requirements, the complexity of the system, and the number of components or subsystems that will need to be integrated to create the system. In addition, it is important to understand whether there will be a desire to add new sensors and effectors in the future. Will the system be used long enough to envision the need for major updates? If long-term operation and evolving mission needs are expected, the investment in an open architecture system will pay off many times over in the long run.

If it is determined that an open architecture system makes sense for the requirements, there are several additional considerations before acquiring, as described below.

Real time versus non-real time. Middleware separates the software applications from the underlying hardware. A fundamental aspect of an open architecture system is the decoupling of the hardware and the software. In order to meet real time requirements, there are currently limited middleware standards that are capable of meeting real time requirements. Non-real time systems offer a broader set of middleware options.

Clearly defining open. Buyers often make statements that the system must have an open architecture without clearly defining what open architecture means to them. The characteristics identified above help define the minimum amount of definition.

Data rights. The government typically owns data rights to systems developed with government funding. It is particularly important to exercise data rights at the system interfaces and exclude contractor proprietary content at the interfaces. Those are the points of the system used to maintain flexibility and the opportunity to maintain and stimulate competition in throughout the life of the program.

Open business model with an open architecture. Buyers who require an open architecture system without any intent of implementing an open business model severely limit future competition and alternatives to maintain their system. Stimulating third party involvement in bringing new capabilities to the solution space and keeping an overall competitive environment is extremely beneficial to the buyer. It keeps costs down and increases the ability to accept new capability.

Leveraging someone else's open architecture without tailoring to the buyer's needs. Sometimes a buyer will take some other buyer's list of requirements for an open architecture system without tailoring it to their specific needs. This is an example where one size does not fit all. Engaging an open architecture expert to evaluate the requirements that are being placed on providers is important.

The true test of an open architecture system is if a third-party provider can develop an application or replace a defined subsystem without support from the system provider.

New System Acquisition/Development versus Modification of Legacy Systems

Acquisition and development efforts fall into generally two categories, new development and modification of a legacy system. New development and modification of legacy systems present unique challenges in the realm of open architecture.

New development. In many ways new development is much easier than modification of a legacy system. It essentially offers a clean sheet of paper from which to begin. In new development the opportunity exists to define an open architecture that meets the overall needs of the system being delivered. Processes, standards, interfaces, and methodology are identified for the system being developed and maintained. The challenge usually arrives when faced with integrating existing subsystems with pre-defined interfaces. In these cases, the architecture must be defined in a way to accommodate the existing systems and yet be adaptable enough to add new subsystems.

Legacy system modification. Several challenges arise when attempting to apply open architecture principles to an existing legacy system. Existing systems often have closed (proprietary) architectures with poorly defined interfaces. This is especially true for complex systems designed in the 1970s and 1980s. Computing power during that time period was very limited and systems required tightly coupled and integrated computing architectures to meet the system requirements. When the architecture of the system is closed, migrating the system to an open architecture often requires significant cost and takes significant effort. Modern tools can be used to reverse engineer much of the code, and software adapters are built to allow legacy software subsystems to run on modern processor architectures.

Definitions

- **Open**. An open system has exposed interface definitions, is receptive to new capabilities, integration into the system is direct, and fundamentally not closed.
- **Architecture**. The method used to build something. In this case, the approach used to interconnect the different subsystems of a system.
- **Subsystem/component**. A part of a larger system that has a defined interface and functionality.
- **System**. A set of components/subsystems that are connected together to form an overall system to meet a system level requirement.
- **Open architecture**. Architecture designed to facilitate introduction of new capabilities over the life cycle of a system. Third-party providers have access to and easily understand application interfaces.
- **Open architecture system**. A system designed to easily incorporate new capabilities and technologies without significant architecture modifications.
- **Open business model**. Using the benefit of having an open architecture system to introduce competition into the acquisition process for new system capabilities. Published interfaces become standards for the program and third parties can invest to develop new capabilities that could be incorporated into the system. Open business models stimulate competition throughout the lifecycle of the program.

Appendix D. Candidate Pilot Programs to Demonstrate Adaptable Approaches

Army Led Program—Ground Combat Vehicle

The Ground Combat Vehicle Program is taking a new approach to fulfilling the Army's need for a new combat vehicle. The program will reach Milestone A shortly, and this represents an ideal opportunity to implement a process change that aligns the development with the Army's Force Generation (ARFORGEN) model cadence and uses a functional development team to align the enterprise processes with the operational cadence.

The Army has developed the requirements for the Ground Combat Vehicle to replace the Bradley Fighting Vehicle for the Heavy Brigade Combat Team and programmed for it to be fielded in seven years. The Secretary of Defense has stated that he would like it to be fielded in five years. The Defense Science Board recommends that the program be declared a pilot to demonstrate an affordable approach to trade performance and risk to meet cost and schedule.

Unit Designation

At Milestone A, the Army should designate a specific user organization based on the ARFORGEN model. While this designation may be changed to meet operational demands, once trade studies are conducted it is recommended that the unit remain tied to the developmental program. This approach ensures the unit in the ARFORGEN cycle participates in the development and operational testing as part of their reset, training, and deployment. Production schedules will be synchronized with the deploying unit's training schedule, and performance trades will be conducted at decision points that will ensure the unit receives vehicles in adequate time to train and deploy into either a combat mission or exercise, which will provide feedback to the next block improvement.[132] The minimum level of unit designation is the battalion.

132. These are proposed as "Good Idea Cut-Off Dates," a term coined during the Division XXI experiments that allowed the division commander in collaboration with U.S. Army Training and Doctrine Command to defer developments in order to conduct training.

Functional Development Team

Prior to Milestone A, a functional development team will be designated with empowered representatives from the Army's Training and Doctrine Command; Forces Command; the program management office; compliance advocates (programmer, comptroller, operational test and evaluation, general counsel, and others); the intelligence community; and the Army Materiel Command. A leader from the Army Staff at flag rank should be designated by the Vice Chief of Staff of the Army by Milestone A.

Key Performance Parameters

The functional development team should be empowered to minimize key performance parameters (KPPs) and to trade performance and risk to meet cost and schedule. KPPs designated at Milestone A will be reviewed by red/blue teams at each key design point (*i.e.*, preliminary design review, critical design review) and milestone. If a KPP or major performance factor is traded, a decision will be made simultaneously to align to a block improvement and funds allocated accordingly. Trades will be conducted utilizing simulations and will be verified in prototype field tests to meet the deployment schedule.

Block Upgrades

A key to success of this approach is the continuous use of block upgrades to increase performance and adapt to threat changes. Trades that cannot be implemented in the initial operating capability will be incorporated at the first block improvement that the program office deems to be executable. Testing will be adjusted simultaneously and program funding will be aligned with the necessary deployment dates.

For this approach to be successful, an enterprise-wide plan must be developed, funded, and executed throughout the life-cycle of the equipment. This will require the testing community to evaluate performance and categorize their assessments as capabilities and limitations rather than evaluate in a binary "suitable or unsuitable" category. The functional development team will define the inputs to further block improvements based upon operational necessity and technical maturity.

Funding

The program office must have the ability to adjust funding across the entire doctrine, organization, training, materiel, leadership, personnel, and facilities domains based upon the ARFORGEN deployments.

Engagement with congressional interests is a key to making this work. The constitutional authority to raise and equip the force gives Congress a strong voice, and the Secretary of Defense should enlist their support. The defense authorizing and appropriations committees must be informed of this approach at Milestone A, and kept abreast of this effort throughout the process.

Air Force Led Program—An Adaptive Strategy for a Long-Range Strike Family of Systems

The Department's *airborne* Long-Range Strike (LRS) Family of Systems (FoS) consists of bombers, C^3ISR (command, control, communications, intelligence, surveillance, and reconnaissance), and munitions—many of which are roughly twenty to over fifty years old. The DSB Summer Study examined the LRS FoS modernization problem as a working example to illustrate how to apply its recommendations on enhancing adaptability in the Department. Applicable recommendations for the LRS FoS include:

- Develop a *shared mission outcome* across the DOD enterprise, including use of a *Secretary's Council* to drive strategic action.
- Form a *functional design team* to define and execute the program(s).
- Use *hedges* to actively *manage risk* across selection and acquisition of capabilities.
- Use *block upgrades* in response to evolving conditions and needs.
- Use *modular architectures* and *continuous competition* to enhance flexibility and lower cost.

While the overall approach used to examine the LRS FoS issue will be familiar to DOD executives (Figure D-1), execution of this approach differs from the norm. The approach began with considering the range of potential objectives for the LRS FoS. The distinctions and trade-offs among these objectives are not obvious and were found to have first-order implications for the LRS FoS design, time-to-field, flexibility, and cost. By understanding these trade-offs, it is possible to define: core outcomes and capabilities;

key areas for flexibility, operational agility, growth margins, and blocks of future capability; and, equally importantly, combinations of capability and performance goals that should *not* be concatenated. Next, we identified an LRS FoS strategy (*i.e.*, ends, ways, and means) for achieving the desired mission outcomes within acceptable cost bounds. We then addressed the range of LRS FoS system alternatives, and triaged these alternatives. Certain alternatives were removed from consideration due to mismatch to the desired outcomes and strategy, while others were highlighted as promising.

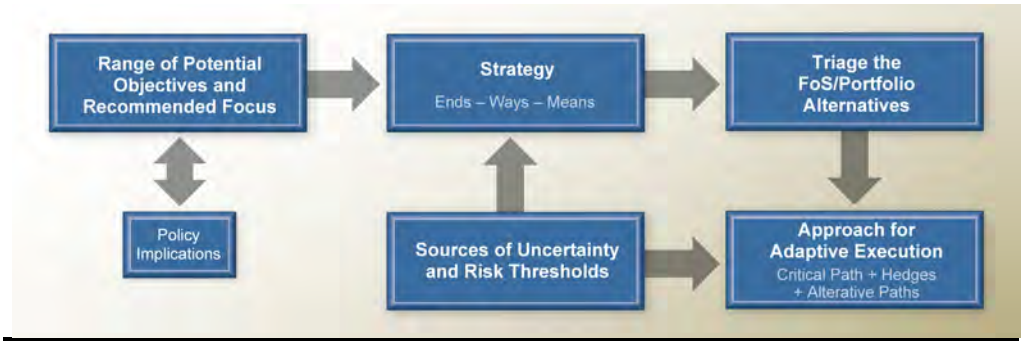

Figure D-1. Overall Approach

Before proceeding to an LRS FoS program strategy, we first identified the sources of uncertainty that impacted not just system design, but also core outcomes and strategy. Desired outcomes, flexibility/agility goals, as well as the LRS alternatives themselves were then modified as necessary. During these deliberations, we bounded the severity, probable timing, and consequences of these uncertainties. This shed light on both relative importance and available time to respond to each uncertainty. Probable consequences and timing was then used to identify which uncertainties to target with hedges. We developed hedges not just to "buy down risk," but, equally importantly, to buy time and defer premature commitment of resources. Deferring such commitments (when feasible) has multiple benefits. It tends to provide temporal flexibility and allow for flatter, more manageable budget profiles. It allows for more options to be kept open in the early stage of a program. More importantly, it reduces sunk-costs, which tend to exert undue influence on subsequent program decisions. Excessive sunk-costs in the face of major uncertainties are obviously undesirable. Worse still, they become major political and intellectual obstacles to sound decision-making as the program proceeds. Last and most important in defense programs, we used hedges to create opportunities for cost-imposition on our adversaries. We purposefully crafted and kept open multiple design options, each of which would be quite expensive for the adversary to counter.

Finally, we assembled a program strategy for the LRS FoS. This strategy was composed of main lines of development, multiple hedge investments, and future alternative development paths emanating from these hedges. These developments and options were time-ordered and structured into blocks of capability. By keeping options and lines of development open, farther into the future, we intentionally retained multiple sources of competition through much of the life of the program. We also sought to impose cost on our adversaries, as described above.

Since the DSB's look at the LRS FoS problem was limited to a few months of effort by a handful of part-time personnel, we did not seek to quantify mission effectiveness, technical performance, cost, or schedule. A real-world LRS FoS program would be tasked by the Secretary's Council, and would establish a functional design team. This team would include, at a minimum: warfighters from Global Strike Command and U.S. Strategic Command, acquirers from SAF/AQ (Secretary of the Air Force/Acquisition) and Air Force Material Command, and budgeteers from the Air Staff/Strategic Plans and Programs (SAF/A-8) and the Office of the Secretary of Defense. The team and program office would employ high-level, parametric models of mission-effectiveness and cost-imposition for the design options of interest. Selected data for these high-level analyses would be developed from engineering level simulations and potentially live experiments and exercises. This analysis would characterize the bounds (*i.e.*, lower, most-likely, upper) on performance and outcomes over time. It would also bound the cost and schedule of the major design options and program strategies. Probabilistic effectiveness and cost estimates would then be used in a two-stage, stochastic, non-linear programming analysis to select and set the resource levels for the preferred LRS FoS design, hedges, and program budgets.

Navy Led Program—Littoral Combat Ship Modules

Littoral Combat Ship (LCS) modules are small surface vessels intended for operations in littoral waters. The basic LCS concept emphasizes speed, shallow draft, and modules customized for various Navy missions. There are two types of LCS hulls: (1) a steel planing hull built by Lockheed-Martin at Marinette in Wisconsin, and (2) an aluminum trimaran built by Austal USA with General Dynamics as the lead contractor. Lockheed-Martin built LCS 1, which has been commissioned and is operating on the West Coast, and is currently building LCS 3. General Dynamics (with Austal) built LCS 2, which has been commissioned but is still undergoing shakedown trials on the East Coast, and is building LCS 4 in Mobile, Alabama.

Mission Modules

As of this writing, there are three module types planned for LCS: mine countermeasures (MCM), anti-submarine warfare (ASW), and surface warfare. The MCM module is the most mature—organic MCM systems were being developed before LCS was initiated. The MCM module currently is planned to contain the MH-60S helicopter employing: the Airborne Laser Mine Detection System; the AN/AQS-20 Minehunting System (four acoustic sensors and one optical sensor); the Airborne Mine Neutralization System, based on the Archerfish mine disposal system (wire-guided mini-torpedo); the Remote Minehunting System, towing the AN/AQS-20; the Unmanned Surface Vehicle, towing an influence sweep; and the Vertical Takeoff Unmanned Aerial Vehicle, with the Coastal Battlefield Reconnaissance and Analysis sensor. The ASW module plans to use unmanned surface vehicles, active sonar, and a distributed passive acoustic system. The Navy is currently buying one MCM module and two surface warfare modules.

Proposed Approach

The Navy program office should consider an acquisition strategy that ties delivery of mission modules to LCS deployments. Specifically, as the fleet begins to receive LCS platforms, the relevant type commander and the acquisition office should agree upon delivery of specific modules per hull to meet deployment schedules. For example, a specific fleet will negotiate with the program office for what specific mission module will be available for each deployment. To the extent possible, mission modules should be customized for the needs of the deployment. For example, the ASW mission module could be modified with a specific active sonar type consistent with the planned geographic and seasonal deployment and acoustic environmental characteristics (*e.g.*, noise or sound velocity propagation).

Appendix E. Selecting Adaptable Military Personnel: A Research Agenda

This appendix identifies a program of research to determine how components of adaptability could be identified, tested, and strengthened in military and civilian personnel.[133] The principal focus will be on military personnel, but findings from both military and civilian contexts should each have value for the other. A complete research agenda would address both selection and training applications, but this plan addresses only selection.

The program has the following elements:

1. Construct a developmental model of adaptability.
2. Develop individual difference measures to predict adaptable performance.
3. Develop measures of adaptable performance.
4. Validate predictor measures against performance measures.
5. Refine measures and strategies, as needed, based on findings.
6. Make recommendations to DOD, based on findings.

Construct a Developmental Model of Adaptability

In order to enhance adaptability in the military and civilian population, it is necessary to understand the process of developing adaptability. A rough working model needs to be developed—not a complex model, but a way of thinking about this topic.

At a starting point, it is reasonable to identify the following general categories of variables that are likely to influence adaptability: individual differences, experience, and context. As the model develops, it can be used to define the variables more completely and begin to generate hypotheses about the relationships among these variables and their direct effects, and interactions pertaining to adaptable performance.

133. This appendix was prepared by Michael G. Rumsey, U.S. Army Research Institute for the Behavioral and Social Sciences.

The term "developmental model" suggests that adaptability is not viewed as a behavior to be observed at a single point in time, but rather a set of responses that are continually developed over time. While individual differences account for some variance in predicting adaptable behavior, as individuals learn differentially from their experiences in varied contexts, their behavior will change. Each experience will have some effect, so the process is unending for the duration of an individual's life.

Individual differences can be conceptualized as independent variables having a direct effect on adaptable performance. Experience and context may be considered to be intervening variables. They may mediate or moderate the effect of individual differences on performance, and they may also have direct effects on performance.

Consider each category of variables expected to play a role in influencing adaptable performance, and then examine adaptable performance itself.

Individual differences. Successful adaptive performance "likely results from a combination of cognitive, temperament, and motivational factors." (Rumsey 1995, p. 139) Pulakos, *et al.* (2002) found that cognitive ability (r = .13), emotional stability (r = .17), and achievement motivation (r = .31) predicted ratings of adaptive performance for 730 military personnel in a variety of occupations. Kilcullen, *et al.* (2002) found that peer-rated performance of officers participating in a Special Forces Robin Sage exercise was predicted by leadership self-efficacy (r = .40), achievement orientation (r = .39), intellectual openness (r = .37), and tolerance of ambiguity (r = .34). The relevance of these findings is that this exercise was designed to require participants to react to changed circumstances.

While these findings offer some basis for identifying individual difference predictors of adaptability, they are only a start. Further exploration of both the cognitive and non-cognitive domains is needed to determine if those attributes likely to be associated with adaptability have been fully covered. While traditional measures of cognitive ability, such as measures of verbal and mathematics ability, may have some utility for this purpose, they are not specifically designed to predict adaptability. A measure of mental flexibility, or of pattern recognition, which has been linked to mental flexibility (Matthew & Stemler (draft)), may have more direct relevance. Cognitive complexity—"a style of thinking incorporating the ability to use several independent dimensions of perception, judgment or behavior and the ability to integrate across dimensions"—(adapted from Peterson, *et al*. 1993, p. 31), also deserves consideration (Rumsey 1995). Burns and Freeman (2008) have suggested consideration of intuition and critical and creative thinking.

A review of non-cognitive dimensions may yield some others besides the ones already shown to be promising, such as ego resiliency and emotional control (Mumford, *et al.* 1993). Burns and Freeman (2008) suggested examining relational skills, including self-awareness and social skills, and Matthews (2007, cited in Burns and Freeman 2008) suggested a consideration of resilience, hardiness, and grit.

Personal experience. Pulakos, *et al*. (2002) found a strong link between experience and adaptive performance. They examined eight types of experience, linked with their eight dimensions of adaptability, and found that one—learning work tasks, technologies, and procedures—correlated .22 with adaptive performance.

Having evidence that experience relates to adaptability is the first step. The next step is determining how to optimize this relationship. Pattern recognition, discussed above with respect to individual differences, can be used to compare new experiences with old ones, and make judgments about whether lessons learned from earlier experiences apply to the new ones. Meta-cognitive and self-regulatory skills can be applied to ensure one is applying active learning strategies (Kozlowksi 1998). Feedback from others can also be important in the learning process. Where one does not directly observe the consequences of one's behavior, or cannot effectively evaluate it, a wise observer can provide guidance. However, the manner in which this guidance is provided, and the recipient's receptiveness, are also important variables in this process.

Context. Contextual variables may directly inhibit or enhance adaptable performance, they may mediate or moderate the relationship between individual difference variables or experience and performance, or they may be involved in the relationship between predictors and performance in an even more complex manner. Some relevant contextual variables might include:

- How much control does the individual have in the situation? How much is he or she limited in adapting to change by superiors? By organizational constraints?
- At what level does the individual operate within the organization? Worker/enlisted level? Lower management/supervisor? Middle management? Upper management?
- What personnel and material resources does the individual have to use in adapting to change?

- What is the quality of the relationships between the individual and superiors and subordinates, and how do these relationships affect ability to adapt to change?
- What contingencies are associated with adaptive versus non-adaptive responses?
- Does the context require adaptable performance? Some work environments, particularly at lower organization levels, may require very little in the way of adaptable performance or may discourage it.

Adaptable performance. Mueller-Hanson, *et al.* (2005) defined adaptability as "effective change in response to an altered situation." Pulakos, *et al*. (2002) identified the following dimensions of adaptability:

- Handling emergencies or crisis situations.
- Handling work stress.
- Solving problems creatively.
- Dealing with uncertain and unpredictable work situations.
- Learning work tasks, technologies, and procedures.
- Demonstrating interpersonal adaptability.
- Demonstrating cultural adaptability.
- Demonstrating physically oriented adaptability.

This taxonomy has both strengths and weaknesses. It is basically empirical: it started with observations of adaptive behavior, then proceeded based on a determination of how these behaviors were found to cluster together. However, it has conceptual limitations. A rational approach to developing taxonomy might focus on describing those characteristics of adaptive behavior that might relate more logically to individual differences, thus providing a more promising basis for linking adaptability to personnel selection and assignment.

Consider how such taxonomy might be constructed. First, go back to the definition: "effective change in response to an altered situation." What are the critical questions prompted by that definition? These might include the following:

- Level of complexity of situation involved.
- Degree to which the situation has been altered.

- Nature of the alteration:
  - Different stimuli?
  - Greater complexity?
  - Greater urgency?
  - Greater importance?
  - Changed contingencies?
  - Greater or lesser environmental support?
  - Level of social involvement?

In order to understand adaptability, and in particular to understand what constitutes an "effective change," these dimensions would seem to be as important as those dimensions identified by Pulakos, *et al.* Thus, while earlier research offers a start to an understanding of adaptability, further work is clearly needed.

Model. Development of a complete, fully specified, and quantitatively exact model is not possible given the limited data available. At the outset, the goal should be to develop a very general, heuristic model that can be modified as more data are accumulated.

Develop Individual Difference Measures to Predict Adaptable Performance

It was suggested above that successful adaptive performance likely results from a combination of cognitive, temperament, and motivational factors. General measures of cognitive ability, such as the Wonderlic, the Armed Forces Qualification Test, and the Scholastic Aptitude Test, already exist. The measures of mental flexibility and pattern recognition discussed above are more experimental, and will need further refinement and examination.

To measure temperament and motivational factors, the Army has developed the Assessment of Individual Motivation (AIM), the Rational Biodata Inventory (RBI), and the Tailored Adaptive Personnel Assessment System (TAPAS), all of which have been shown to effectively predict a variety of important performance outcomes. The RBI, in particular, has been linked to what could reasonably be viewed as adaptive performance based on research relating RBI scores to job performance in Special Operations Forces (Kilcullen, *et al*. 1999), and the test measures many of the same dimensions as the AIM and the TAPAS. The AIM and the TAPAS are particularly well designed to counter faking by use of a forced choice format. The TAPAS has a flexible

design enabling the generation of hundreds of thousands of items, and, because of its adaptive approach, is difficult to compromise and can be administered in a short period of time. Although many relevant dimensions are already included in TAPAS, further development of items in such areas as intellectual openness would be advisable. Cognitive complexity has both cognitive and temperament aspects, so it presents particular measurement challenges.

Develop Measures of Adaptable Performance

As noted above, adaptable performance is a multi-faceted concept, affected by a wide variety of situational factors. Thus, prior to measure development, additional attention to fully specifying the concept and the factors influencing it are needed.

In order to have meaningful measures of adaptability, it is desirable that those evaluated are actually placed in situations where adaptable performance is elicited. Ratings of an individual's adaptability is not particularly meaningful since the person being rated has not generally been confronted with "altered situations." These situations may occur naturally, or they may be manipulated. If an individual has a job or an assignment where situations change frequently, then a rating of adaptable in that context may be meaningful. If change is introduced into the situation, it allows some control over the type and degree of change.

Research has revealed two general types of performance. One involves proficiency, and is manifested in such maximal performance measures as hands-on tests. Such measures have been termed measures of "can do" performance. The other type is more reflective of a person's motivation, and is addressed by ratings and such administrative measures as awards and incidents of misbehavior. Such measures have been termed measures of "will do" performance. To obtain a full view of a person's performance, it is important to have both.

Validate Predictor Measures Against Performance Measures

The next step is to determine whether the individual difference measures predict adaptable performance. The validation strategy will be guided by the intended use of the individual difference measures. Adaptability is particularly important for leadership jobs, where one has an elevated responsibility for dealing with the altered situation, and particularly challenging jobs, such as those in Special Forces. It is also important with respect to combat assignments, where one has to

deal with the "fog of war." Thus, these types of jobs and assignments should receive first consideration when developing a validation plan.

Ideally, the validation would be conducted in multiple contexts. For purposes of demonstration, let us consider one: Army Special Forces. One would administer the individual difference measures when the individual applies to Special Forces. Then, at later points, the performance measures would be administered. These points should include Special Forces assessment and selection, an extended exercise prior to selection, Robin Sage, an extended exercise at the end of training, and on the job, perhaps 12 to 18 months after completion of training. The performance measures would be designed to reflect the particular manner and extent of the alteration of the environment to which the soldier had to adapt, as well as the manner in which that alteration might be expected to impact the soldier's performance. The relationship between the individual difference measures and the performance measures would provide evidence of the potential utility of using the individual difference measures for selection in this particular context.

Other validation research in other contexts could provide evidence for expanded use of these measures. For officer leadership, tests could be administered to pre-commissioning candidates and validated in a longitudinal design against performance and advancement in the Army. The Job Adaptability Inventory (Pulakos, *et al.* 2000) could be used to provide a basis for identifying other contexts for adaptability test validation.

Refine Measures and Strategies, as Needed, Based on Findings

Results from the validation research on the selection tools will likely provide some indication of needed changes to these tools. Thus, the plan should build in the opportunity to update and improve the assessment battery and then re-examine its validity.

Make Recommendations to DOD, Based on Findings

The final step in this plan is to make recommendations concerning changes to current selection procedures based on the findings. Depending on the results, the changes could be modest or dramatic. While the most likely implementations would be in the context of Special Forces and officers, the validation research conducted on the individual difference measures could provide a basis for using these for enlisted selection, classification, or both.

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Appendix F. Two Track Research and Development, Production, and Deployment Concept

This report features an important concept related to adaptability: hedging. It is invoked as an appropriate mechanism to address future U.S. national security needs given high uncertainty. In particular, many forecast that the near-to-intermediate-term national security paradigm will most likely be one of counter-terrorism and counter-insurgency involving 2nd or 3rd tier states and non-state actors, frequently conducted among civilian populations in remote locations. While adapting the U.S. national security strategy and posture to confront these realities effectively, the United States cannot ignore the possibility of a force-on-force confrontation with near peer competitors—Russia or China—sometime in the future. Such a confrontation could have existential implications for the United States, and, therefore, would represent a worst case outcome for the nation. The stakes are extremely high; hence, a proposal to proceed with re-posturing the U.S. national security infrastructure to address the most likely of the possible futures as outlined above, while hedging against a near-peer confrontation, perhaps ten years out, is offered.

As is obvious to most, the current U.S. national security infrastructure has its origins in the Cold War stand-off with the former Soviet Union, and still has many artifacts from those origins. Bureaucratic processes in the DOD, the weapons systems procured and employed, the organization of forces, and the alignment of the industrial base, all are optimized to prepare for and execute a near-peer confrontation with a resurgent Russia (or emergent China). As a result, the Department has struggled to gain effectiveness from these processes, doctrines, and systems in the Iraq and Afghanistan theaters—giving rise to this summer study on adaptability. A good amount of re-optimization of DOD processes, doctrine, organization and systems is seen to be in order. The likely range of futures would seem to require more mobility, more agility, and more flexibility, to be traded off against capabilities in firepower, defensive "heft," exquisite performance, or mass formation executions. The hedge against a near-peer confrontation would require that DOD preserve the ability to regenerate a force with these attributes and capabilities.

A two-track approach for R&D, deployment, and sustainment is suggested.

Track 1:

- Maintain a high degree of worldwide situational awareness and certain critical national capabilities (*e.g.*, nuclear capability and deterrence; C5I (command, control, communications, computers, collaboration, and intelligence); air and sea lift; ground nuclear detection system terminals; space). Some reductions in capacities might be appropriate, but performance leadership must be maintained, as well as the ability to regenerate full capacity.
- Conduct R&D to maintain state-of-the-art capabilities in those additional areas projected to be necessary to prevail in a near-peer, force-on-force confrontation with Russia or China. These capabilities would include high performance aircraft, armor, ships, missiles, and other weapons, and perhaps other specific elements.
- Produce modest volumes of even the highest performance military elements and systems so that the United States doesn't lose its technical edge, and so that the capabilities in the government and the industrial base retain their ability to regenerate and employ the heavier and more capable force. The recent decision on F-22 would seem to be a perfect model going forward. The F-22 is the world's most capable air superiority fighter, and is being produced and deployed in modest numbers. At some point in the future, an R&D program should be initiated to develop the successor to the F-22, and to produce and deploy some number of them, and so on. Likewise with other elements of the "heavier" force structure—the M1A2, main battle tank, being a classic example.

Track 2:

- Using lessons learned from the conflicts in Iraq and Afghanistan, along with extrapolations to account for the range of possible engagements under the "new" national security paradigm, develop definitions of a more mobile, more agile, more flexible, force structure. Conduct reviews of the defense program of record to ascertain which elements of the current and near-term plans are good fits, either directly or with modest adaptation, for the new force structure. Those poorly suited for the "new" paradigm should be sunsetted or moved to the Track 1 approach. It is axiomatic that new equipments and systems will need to be lighter, more transportable, more

mobile, more flexible, and intended for offer to allies and potential coalition members. F-35 would seem the appropriate fighter aircraft for the new world (vice F-22). It is multi-service, multi-role (including vertical and/or short take-off and landing) and has allied participation.

- Initiate aggressive R&D to develop new or adapted elements for the new force structure. Production should be done to achieve required volumes in reasonable time frames, but high rate, "one shot" procurements should be avoided in favor of lower rate, continuous production. Deployment into the force should not be according to a one-size-fits-all model.
- Organization, doctrine, mobilization, training, sustainment, etc. should be developed to allow a lego-like creation of units matched to near term employment requirements. All units need not be identically equipped or purposed.

This two-track approach would keep the United States at the forefront of critical war fighting capabilities, allow a re-optimization of the U.S. national security infrastructure to better match the near- to intermediate-needs and preserve the ability to regenerate a near-peer, force-on-force capability in a reasonable time (~10 years) by maintaining the government and industry workforces and capabilities. The hope would be that this approach would offer opportunities for cost savings, but would most certainly be less expensive than trying to maintain a force structure fully capable of either mode on short notice.

Glossary

AIM	Assessment of Individual Motivation
AIP	[Navy] Assignment Incentive Pay [program]
AMD	advanced micro devices
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AoA	analysis of alternatives
ARCI	Acoustic Rapid COTS Insertion [program]
ARFORGEN	Army Force Generation [process]
ASD (RA)	Assistant Secretary of Defense for Reserve Affairs
ASVAB	Armed Services Vocational Aptitude Battery
ASW	anti-submarine warfare
AWACS	Airborne Warning and Control System
AWG	[Army] Asymmetric Warfare Group
C3I	command, control, communications, and intelligence
C3ISR	command, control, communications, intelligence, surveillance, and reconnaissance
C4I	command, control, communications, computers, and intelligence
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
C5I	command, control, communications, computers, collaboration, and intelligence
CAD	computer-aided design
CAOC	Combined Air Operations Center
CDD	Capability Development Document
CEO	Chief Executive Officer
CIA	Central Intelligence Agency
CJ2	Combined Joint Staff Branch for Intelligence
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CONOPS	concept of operation
COTS	commercial off-the-shelf
CSH	Combat Support Hospital
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DIA	Defense Intelligence Agency

DDR&E	Director, Defense Research and Engineering
DIOSPO	Defense Open Source Program Office
DLIFLC	Defense Language Institute Foreign Language Center
DNI	Director of National Intelligence
DOD	Department of Defense
DRAM	dynamic random access memory
DSB	Defense Science Board
FAO	foreign area officer
FBCB2	Force XXI Battle Command Brigade and Below
FCS	Future Combat System
FoS	Family of Systems
GAO	U.S. Government Accountability Office
GED	General Education Development
GM	General Motors
GPS	Global Positioning System
HASC O&I	House Armed Services Committee Subcommittee on Oversight & Investigations
HMMWV	high mobility multipurpose wheeled vehicle
HQE	Highly Qualified Expert [authority]
IC	intelligence community
IDA	Institute for Defense Analyses
IED	improvised explosive device
IOC	initial operational capability
IWS	Integrated Warfare Systems
IPA	Intergovernmental Personnel Act
IPT	integrated product team
IPTV	Internet Protocol television
ISR	intelligence, surveillance, and reconnaissance
IT	information technology
JCIDS	Joint Capabilities Integration and Development System
JFCOM	U.S. Joint Forces Command
JIEDDO	Joint Improvised Explosive Device Defeat Organization
JROC	Joint Requirements Oversight Council
JTIDS	Joint Tactical Information Distribution System
JUON	joint urgent operational need
KPPs	key performance parameters

LAN	local area network
LAV	Light Armored Vehicle
LCS	Littoral Combat Ship
LRS	long-range strike
MCM	mine countermeasures
MDA	Missile Defense Agency
MHAT	Mental Health Advisory Team
MRAP	Mine Resistant Ambush Protected [vehicle program]
MSIP	Multinational Staged Improvement Program
NASIC	National Air and Space Intelligence Center
NATO	North Atlantic Treaty Organization
NAVSEA	Naval Sea Systems Command
NCAPS	Navy Computer Adaptive Personality Scales
NGA	National Geospatial-Intelligence Agency
NIPF	National Intelligence Priorities Framework
NLSC	National Language Service Corps
NMEC	National Media Exploitation Center
NSA	National Security Agency
NSLI	National Security Language Initiative
NRO	National Reconnaissance Office
ODNI	Office of the Director of National Intelligence
OODA	observe, orient, decide, act
OSD	Office of the Secretary of Defense
OSINT	open source intelligence
OSW	Open Source Skunk Works
OT&E	operational test and evaluation
OUSD (AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology and Logistics
PACOM	U.S. Pacific Command
PC	personal computer
PEO	program executive office
PEO IWS	Program Executive Office for Integrated Warfare Systems [Navy]
PMO	program management office
PNT	precision, navigation, and timing
POM	program objective memorandum
PTSD	post traumatic stress disorder

QDR	Quadrennial Defense Review
R&D	research and development
RASER	Rapid Analytical Support and Expeditionary Response
RBI	Rational Biodata Inventory
RFP	request for proposal
ROTC	Reserve Officer Training Corp
SAF/A-8	Air Staff/Strategic Plans and Programs
SAF/AQ	Secretary of the Air Force/Acquisition
SHARP	Summer Hard Targets Program
SOCOM	U.S. Special Operations Command
SOF	Special Operations Forces
SPO	system program office
SRAM	static random access memory
SSA	space situational awareness
SSBN	ballistic missile submarine
STRATCOM	U.S. Strategic Command
SWAP	size, weight, and power
TAP	Test of Adaptable Personality
TAPAS	Tailored Adaptive Personality Assessment System
TS/NOFORN	Top Secret/Not Releasable to Foreign Nationals
TTPs	tactics, techniques, and procedures
TUAV	Tactical Unmanned Aerial Vehicle
UAV	Unmanned Aerial Vehicle
UON	urgent operational need
USAF	United States Air Force
USAID	United States Agency for International Development
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
USD (I)	Under Secretary of Defense for Intelligence
USD (P&R)	Under Secretary of Defense for Personnel and Readiness
USMC	United States Marine Corps
USSOCOM	U.S. Special Operations Command
WMD	weapons of mass destruction