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. The report was in security review from 22 November 2010 to 31 January 2011.

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

DEFENSE SCIENCE BOARD

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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

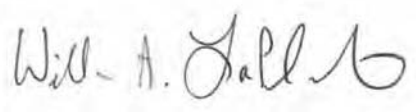
Today's military forces face an increased level of operational uncertainty and must be ready to adapt rapidly. Adversaries evolve in days, weeks, or months, and U.S. forces must be able to adapt in kind—not in decades, as is the timeline of many current processes. However, DOD's lengthy preparation cycles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

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

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]

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

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]

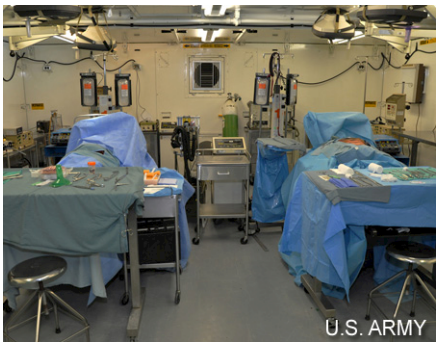
Differentiating Characteristics

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.

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

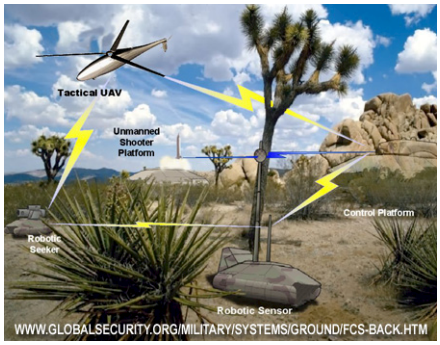
late 2005. In 2006, the F-22's development team won the Collier Trophy, the most prestigious award for American aviation. As of 2010, 168 F-22s had been built and placed in service. A total of 187 are planned to be in service by 2011.

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.

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

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

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

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.

References

A Call to Action for National Foreign Language Capabilities, The National Language Conference, February 1, 2005.

Building Language Skills and Cultural Competencies in the Military: DoD's Challenge in Today's Educational Environment, report of the U.S. House of Representatives, Committee on Armed Services, Subcommittee on Oversight & Investigations, November 2008.

Chairman of the Joint Chiefs of Staff Instruction 3126.01, *Language and Regional Expertise Planning*, 23 January 2006.

Defense Language Transformation Roadmap, (2005).

Joint Operating Environment 2010, *The*, United States Joint Forces Command, February 18, 2010.

McGinn, Gail H., Deputy Under Secretary for Plans and the Department of Defense Senior Language Authority, Statement before the House Armed Services Committee, Subcommittee on Oversight and Investigations, September 10, 2008.

Smith, Dr. Jerome P., Chancellor for Education and Professional Development. (2003). *Defense Language Institute Foreign Language Center, A Report for the Under Secretary of Defense for Personnel and Readiness.*

Quadrennial Defense Review Report, (2006).

Quadrennial Defense Review Report, (2010)

Weaver, Nancy E., Department of Defense Senior Language Authority. Statement before the House Armed Services Committee Subcommittee on Oversight and Investigations, June 29, 2010.

Weaver, Nancy E., Director Defense Language Office, Statement before the United States Senate Committee on Homeland Security and Governmental Affairs Subcommittee on Oversight of Government Management, Federal Workforce and the District of Columbia, July 29, 2010.

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.

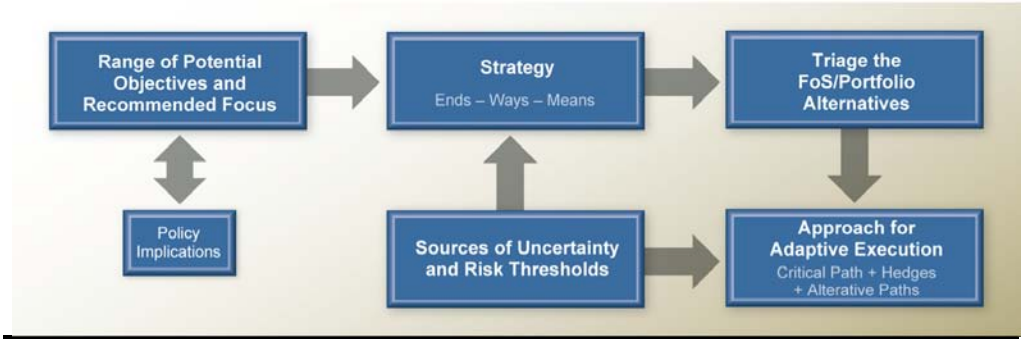

Figure D-1. Overall Approach

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.

References

Burns, W. R. & Freeman, W. D. (2008). *Developing an adaptability training strategy and policy for the DoD: Interim report* (IDA Paper P-4358). Institute for Defense Analyses.

Kilcullen, R., Goodwin, J., Chen, G., Wisecarver, M., & Sanders, M. (2002). *Identifying agile and versatile officers to serve in the Objective Force*. Presented at the Army Science Conference.

Kilcullen, R. N., Mael, F. A., Goodwin, G. F., & Zazanis, M. M. (1999). "Predicting U.S. Army Special Forces field performance." *Human Performance in Extreme Environments*, 4, 53-63.

Kozlowski, S. W. J. (1998). "Training and developing adaptive teams: Theory, principles, and research." In J. A. Cannon-Bowers & E. Salas (Eds.), *Making decisions under stress*. Washington, DC: American Psychological Association.

Matthew, C. T., & Stemler, S. (2008, draft). *Exploring pattern recognition as a predictor of mental flexibility*.

Matthews, M. D. (2007). *Non-cognitive predictors of social adaptability and performance*. Briefing, Adaptability Symposium. Alexandria, Va.

Mumford, M. D., Zaccaro, S. J., Harding, F. D., Fleishman, E. A., & Retier-Palmon, R. (1993). *Cognitive and temperament predictors of executive ability: Principles for developing leadership capacity* (Tech. Rep. No. 977). Alexandria, Va.: U. S. Army Research Institute for the Behavioral and Social Sciences.

Peterson, N. G., Smith, D., Hoffman, R. G., Pulakos, E. D., Reynolds, D., Potts, B. C., Oppler, S. H., and Whetzel, D. L. (1993). Personal communication.

Pulakos, E. D., Arad, S, Donovan, M. A., & Plamondon, K. E. (2000). "Adaptability in the workplace: Development of a taxonomy of adaptive performance." *Journal of Applied Psychology*, 85, 612-624.

Pulakos, E. D., Schmitt, N., Dorsey, D. W., Arad, S., Hedge, J. W., & Borman, W. C. (2002). "Predicting adaptive performance: Further tests of a model of adaptability." *Human Performance*, 15, 299-323.

Rumsey, M. G. (1995). "The best they can be: Tomorrow's soldiers" (pp. 123-158). In R. L. Phillips & M. R. Thurman (Eds.), *Future soldiers and the quality imperative: The Army 2010 conference*. Fort Knox, Ky.: The United States Army Recruiting Command.

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